Columbia River System Operations Final Environmental Impact Statement

Appendix V, Endangered Species Act Consultation

Part 2, NMFS' Endangered Species Act Section 7(a)(2) Biological Opinion for the Continued Operation and Maintenance of the Federal Columbia River Power System

An Endangered Species Act (ESA) consultation was conducted with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) (collectively, the "Services") in concert with the Columbia River System Operations (CRSO) National Environmental Policy Act (NEPA) process. The Preferred Alternative from the CRSO final Environmental Impact Statement (EIS) accordingly forms the basis for the proposed action described in these Biological Opinions (Opinions). The co-lead agencies have chosen to append the Opinions to the final EIS to provide further effects analysis related to ESA-listed species.

It is important to note that NEPA and the ESA establish different standards for legal compliance and have different approaches to the analysis of the effects of the action. Because of these differences, the analyses performed in the final EIS and in the Opinions are tailored to the requirements of each regulatory process.

While the EIS analyzed the effects of the alternatives on all resources, and compares these and the Preferred Alternative to the No Action Alternative, the Opinions examine the effects of the proposed action, which is consistent with the Preferred Alternative, on ESA-listed species and designated critical habitat.

Under the ESA, the USFWS and NMFS made determinations regarding whether the action will jeopardize the continued existence of an ESA-listed species or destroy or adversely modify designated critical habitat.

These Opinions will be available on the NMFS and USFWS websites in a format that complies with the Americans with Disabilities Act (ADA) and Section 508 of the Rehabilitation Act.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232

July 24, 2020

Refer to NMFS No: WCRO 2020-00113

Mr. Roland Springer
Deputy Regional Director
U.S. Bureau of Reclamation
1150 North Curtis Road, Suite 100
Boise, ID 83706

Ms. Frances E. Coffey
Director, Programs
U.S. Army Corps of Engineers
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Portland, OR 97232-1274

Mr. Scott G. Armentrout
Executive Vice President
Environment, Fish & Wildlife
Bonneville Power Administration
905 NE 11th Ave., (MS E-4)
Portland, OR 97232-4169

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Continued Operation and Maintenance of the Columbia River System

Dear Mr. Springer, Mr. Armentrout and Ms. Coffey:

Thank you for your letter of January 23, 2020, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the ongoing operation and maintenance of the Columbia River System (CRS) and associated non-operational measures to offset adverse effects to listed species. The three Federal Action Agencies with responsibility for operating the CRS are the Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (Corps), and the U.S. Bureau of Reclamation (BOR). Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1855(b)).

We appreciate the extensive discussions and informal consultation that informed the development of the final proposed action. We also acknowledge receipt of your letter of April 1, 2020, containing additional information and clarification of the Biological Assessment of Effects of the Operations and Maintenance of the Columbia River System on ESA-listed Species. On May 1, 2020, we shared a draft biological opinion with your agencies for review.

The enclosed document contains a final biological opinion (opinion) prepared by NMFS pursuant to section 7(a)(2) of the ESA on the effects of the proposed action. In the opinion, we conclude that the proposed action is not likely to jeopardize the continued existence of Snake River (SR) spring/summer Chinook salmon, SR Basin steelhead, SR sockeye salmon, SR fall

Chinook salmon, Upper Columbia River (UCR) spring-run Chinook salmon, UCR steelhead, Middle Columbia River steelhead, Columbia River chum salmon, Lower Columbia River (LCR) Chinook salmon, LCR steelhead, LCR coho salmon, Upper Willamette River (UWR) Chinook Salmon, UWR steelhead, and the southern Distinct Population Segment of eulachon. In the opinion, we also determine that the proposed action will not destroy or adversely modify designated critical habitat for the same species. We also concur with the BPA, the Corps, and BOR that the proposed action is not likely to adversely affect Southern Resident killer whales and the southern Distinct Population Segment of green sturgeon or their designated or proposed critical habitat.

As required by section 7 of the ESA, NMFS provides an incidental take statement (ITS) with the opinion. The ITS includes reasonable and prudent measures (RPMs) that NMFS considers necessary or appropriate to minimize the impact of incidental take associated with this action. The ITS sets forth non-discretionary terms and conditions, including reporting requirements, that the Action Agencies must comply with to carry out the RPMs. Incidental take from actions in compliance with these terms and conditions will be exempt from ESA take prohibitions.

The opinion includes ESA conservation recommendations that are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

This document also includes the results of our analysis of the action's effects on EFH pursuant to section 305(b) of the MSA, and includes fourteen Conservation Recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH. Section 305(b)(4)(B) of the MSA requires Federal agencies to provide a detailed written response to NMFS within 30 days after receiving these recommendations.

Please contact Ritchie Graves (503-231-6891 or Ritchie.Graves@noaa.gov), Branch Chief, Columbia Hydropower Branch of the Interior Columbia Basin Office in Portland, Oregon, if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Michael P. Tehan
Assistant Regional Administrator
NMFS West Coast Region

Enclosure

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Continued Operation and Maintenance of the Columbia River System

NMFS Consultation Number: WCRO 2020-00113

Action Agencies: Bonneville Power Administration
U.S. Army Corps of Engineers
U.S. Bureau of Reclamation

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Snake River Spring/Summer Chinook Salmon	Threatened	Yes	No	Yes	No
Snake River Basin Steelhead	Threatened	Yes	No	Yes	No
Snake River Sockeye Salmon	Endangered	Yes	No	Yes	No
Snake River Fall Chinook Salmon	Threatened	Yes	No	Yes	No
Upper Columbia River Spring-Run Chinook Salmon	Endangered	Yes	No	Yes	No
Upper Columbia River Steelhead	Threatened	Yes	No	Yes	No
Middle Columbia River Steelhead	Threatened	Yes	No	Yes	No
Columbia River Chum Salmon	Threatened	Yes	No	Yes	No
Lower Columbia River Chinook Salmon	Threatened	Yes	No	Yes	No
Lower Columbia River Steelhead	Threatened	Yes	No	Yes	No
Lower Columbia River Coho Salmon	Threatened	Yes	No	Yes	No
Upper Willamette River Chinook Salmon	Threatened	Yes	No	Yes	No
Upper	Threatened	Yes	No	Yes	No

Willamette River Steelhead					
Southern DPS of Eulachon	Threatened	Yes	No	Yes	No
Southern DPS of Green Sturgeon	Threatened	No	N/A	No	N/A
Southern Resident Killer Whales	Endangered	No	N/A	No	N/A

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Office
NMFS West Coast Region

Date: July 24, 2020

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Terms and Definitions

Abundance	In the context of salmon recovery, abundance refers to the number of adult fish returning to spawn.
Acre-feet	A common measure of the volume of water in the river system. It is the amount of water it takes to cover one acre (43,560 square feet) to a depth of one foot.
Adaptive management	The process of adjusting management actions and/or directions based on new information.
Anadromous	Species that are hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.
Beverton-Holt function	This function predicts the number of progeny that will return to spawn from a given number of parent spawners.
Brood cycles	The juvenile salmon and steelhead produced in a given year will mature at different rates and return to freshwater spawning adults over several years. When all of these progeny have returned to spawn, the brood cycle is complete.
Cleptoparasitism	A form of feeding in which one animal takes prey or other food from another that has caught, collected, or otherwise prepared the food.
Compensatory mortality	Compensatory mortality occurs when predation mortality at one life stage is offset to some degree by decreased mortality at the same or subsequent life stages.
Compliance monitoring	Monitoring to determine whether a specific performance standard, environmental standard, regulation, or law is met.
Delisting criteria	Criteria incorporated into ESA recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (threats criteria based on the five listing factors in ESA section 4[a][1]), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species.
Density dependence	Density dependence refers to the relationship between population density and population growth rate. Density dependence occurs when a change in the number of fish in a given area (fish density) causes a change in the fish population's growth rate. Most commonly, the population's growth rate slows as the number of fish increases, and, in turn, increases as the number of fish decreases. This is termed compensatory density dependence. Compensatory density dependence is typically caused by competition for limiting resources, such as food or habitat. Less common is depensatory density dependence, in which a population’s growth rate decreases at low densities.
Dissolved gas level	As falling water hits the river surface, it drags in air as it plunges. With increasing water pressure, the air dissolves into the water and increases the levels of pre-existing dissolved gases.

Distinct population segment (DPS)	A listable entity under the ESA that meets tests of discreteness and significance according to USFWS and NOAA Fisheries policy. A population is considered distinct (and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, it occupies an unusual or unique ecological setting, or its loss would represent a significant gap in the species' range.
Diversion	Refers to taking water out of the river channel for municipal, industrial, or agricultural use. Water is diverted by pumping directly from the river or by filling canals.
Diversity	All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.
Dredging	The act of removing sediment from the river bottom to keep the channel at the proper depth for navigation. The continual moving and shifting of sediment makes dredging an ongoing activity.
Effectiveness monitoring	Monitoring set up to test cause-and-effect hypotheses about recovery actions: Did the management actions achieve their direct effect or goal? For example, did fencing a riparian area to exclude livestock result in recovery of riparian vegetation?
Escapement	The number of adult fish returning to the spawning grounds.
ESA recovery plan	A plan to recover a species listed as threatened or endangered under the U.S. Endangered Species Act (ESA). The ESA requires that recovery plans, to the extent practicable, incorporate (1) objective, measurable criteria that, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions that may be necessary to achieve the plan's goals; and (3) estimates of the time required and costs to implement recovery actions.
Evolutionarily significant unit (ESU)	A group of Pacific salmon or steelhead trout that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species. Equivalent to a distinct population segment and treated as a species under the Endangered Species Act.
Exploitation rate	Exploitation rate is the proportion of the total number of fish from a given natural-origin population(s) or hatchery stock(s) that die from the result of fishing activity in a given year.

Fish ladder	A series of stair-step pools that enables salmon to get past the dams. Swimming from pool to pool, salmon work their way up the ladder to the top where they continue upriver.
Flood control	Streamflows in the Columbia River Basin can be managed to keep water below damaging flood levels in most years. This level of flood control is possible because storage reservoirs on the river can capture and store heavy runoff as it occurs.
Flow augmentation	Water released from storage reservoirs at targeted times and places to increase streamflows to benefit migrating salmon and steelhead
Freshet	The heavy runoff that occurs in a river when streams are at their peak flows during spring snowmelt. Before the mainstem dams were built, these freshets moved juvenile salmon more quickly downriver (shorter travel time to the ocean compared to the current hydrosystem).
Heterozygosity	The presence of different alleles or variations (e.g., one dominant and one recessive) of a gene at one or more loci on a chromosome.
Hydrologic unit code (HUC)	A Hydrologic Unit Code (HUC), developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country.
Hyporheic zone	The hyporheic zone is a region beneath and alongside a stream bed where shallow groundwater and surface water mix.
Implementation monitoring	Monitoring to determine whether an activity was performed and/or completed as planned.
Intensively monitored watershed (IMW)	An intensively monitored watershed (IMW) is an experiment in one or more catchment basin(s) with a well-developed, long-term monitoring program to determine watershed-scale fish and habitat responses to habitat restoration actions. The goals of the IMW approach are to determine the effectiveness of restoration actions at increasing salmon and steelhead productivity, determine the causal mechanisms of fish responses to restoration, and ultimately extrapolate the results to other watersheds where intensive monitoring is not possible due to limited budgets.
Intrinsic productivity	Productivity at very low population size; unconstrained by density.
Introgression	The incorporation of genes from one species into the gene pool of another as a result of hybridization.
Iteroparity	The ability to reproduce more than once during a lifetime.
Kelts	Steelhead that have survived spawning and may return the following year to spawn again, unlike most other anadromous fish.

Legacy effects	Impacts from past activities (usually a land use) that continue to affect a stream or watershed in the present day.
Levee	A levee is a raised embankment built to keep out flood waters.
Limiting factor	Physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish at the population, major population group, or ESU levels that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity).
Major population group (MPG)	An aggregate of independent populations within an ESU that share similar genetic and spatial characteristics.
Management unit	A geographic area defined for recovery planning purposes on the basis of state, tribal or local jurisdictional boundaries that encompass all or a portion of the range of a listed species, ESU, or DPS.
Minimum abundance threshold	The ICTRT (2007) identified and incorporated “minimum abundance and productivity thresholds” into the viability curves for salmon and steelhead populations using four different population size categories: basic, intermediate, large, and very large. The minimum abundance thresholds reflect the viable salmonid principles provided by McElhany et al. (2000), as well as estimates of the relative amount of historical spawning and rearing habitat associated with each population. They represent the number of spawners needed for a population of a given size category to achieve viability (or a low [5 percent] risk of extinction) at a given productivity.
Morphology	The form and structure of an organism, with special emphasis on external features.
Northern pikeminnow	A giant member of the minnow family, the northern pikeminnow is native to the Columbia River and its tributaries. Studies show a northern pikeminnow can eat up to 15 young salmon a day.
Parr	The stage in anadromous salmonid development between absorption of the yolk sac and transformation to smolt before migration seaward.
Peak flow	The maximum rate of flow occurring during a specified time period at a particular location on a stream or river.
Photic zone	The depth of the water in a lake or ocean that is exposed to sufficient sunlight for photosynthesis to occur.
Piscivorous	Describes any animal that preys on fish for food.
Productivity	A measure of a population’s ability to sustain itself or its ability to rebound from low numbers. The terms “population growth rate” and “population productivity” are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

Proportion of hatchery-origin spawners (pHOS)	Proportion of natural spawners composed of hatchery-origin recruits.
Proportionate natural influence (PNI)	The proportionate natural influence (PNI) measures the degree of dominance of natural-origin fish in a population over time. PNI is calculated as a function of the composition of spawners in the hatchery and in the natural populations over generations.
Quasi-extinction threshold (QET)	The quasi-extinction threshold (QET) is an abundance level greater than 1, which represents absolute extinction, at which there is great concern from a management perspective and high analytic uncertainty regarding persistence. Since there is debate about the exact population level at which this condition occurs, several possible levels (50, 30) are considered. Results from short-term quasi-extinction probability modeling are used to help assess near-term (24-year) extinction risk.
Reach	A length of stream between two points.
Reasonable and prudent alternative	Recommended alternative actions identified during formal consultation that can be implemented in a manner consistent with the purposes of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that are economically and technologically feasible, and that the Service believes would avoid the likelihood of jeopardizing the continued existence of the listed species or the destruction or adverse modification of designated critical habitat.
Recovery goals	Goals incorporated into a locally developed recovery plan. These goals may go beyond the requirements of ESA delisting by including other legislative mandates or social values.
Recovery strategy	A statement that identifies the assumptions and logic—the rationale—for the species' recovery program.
Recruits-per-spawner (*or* returns-per-spawner)	Ratio of progeny surviving to spawn per parent. Generally, if average population growth rates (or productivities) are expected to be greater than 1.0, the population will grow.
Redd	The nest constructed by female salmonids in streambed gravels where eggs are deposited and fertilization occurs.
Resident fish	Fish that are permanent inhabitants of a water body. Resident fish include trout, bass, and perch.
Riparian area	Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.
River reach	A general term used to refer to segments of the river between one point to another, as in the reach from the John Day Dam to the McNary Dam.
Runoff	Precipitation, snowmelt, or irrigation water that runs off the land into a stream or other surface water body.

Salmonid	Fish of the family *Salmonidae*, including salmon, trout, chars, grayling, and whitefish. In general usage, the term usually refers to salmon, trout, and chars.
Smolt	A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt from life in freshwater to the saltwater environment.
Snowpack	The accumulation of snow in the mountains that occurs during the late fall through early spring.
Spatial structure	The geographic distribution of a spawning population or the populations in an ESU.
Spill	Water released from a dam over the spillway instead of being directed through the turbines.
Stakeholders	Agencies, groups, or private citizens with an interest in recovery planning, or who will be affected by recovery planning and actions
Streamflow	Streamflow refers to the rate and volume of water flowing in various sections of the river. Streamflow records are compiled from measurements taken at particular points on the river, such as The Dalles, Oregon.
Technical Recovery Team (TRT)	Teams convened by NOAA Fisheries to develop technical products related to recovery planning. For recovery planning, TRTs are complemented by planning forums unique to specific states, tribes, or regions, which use TRT and other technical products to identify recovery actions.
Threats	Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.
Tule	A fall Chinook salmon that spawns in lower Columbia River tributaries (as opposed to “upriver bright” fall Chinook that spawn above Bonneville Dam).
Turbine	A hydro turbine is a device used in hydroelectric power generation that transfers energy from moving water to a rotating shaft to generate electricity. The turbines rotate or spin as a response to water being introduced to their blades and drive an electric generator to produce power.
Viability criteria	Criteria defined by NMFS-appointed Technical Recovery Teams based on the biological parameters of abundance, productivity, spatial structure, and diversity, which describe a viable salmonid population (VSP) (an independent population with a negligible risk of extinction over a 100-year time frame) and which describe a general framework for how many and which populations within an ESU should be at a particular status for the ESU to have an acceptably low risk of extinction.

Viable salmonid population (VSP)	An independent population of Pacific salmon or steelhead that has a negligible risk of going extinct as a result of genetic change, demographic stochasticity (i.e., random effects when abundance is low), or normal levels of environmental variability.

Abbreviations and Acronyms

°C	degrees Celsius
°F	degrees Fahrenheit
Action Agencies	U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and the Bonneville Power Administration
AEM	action effectiveness monitoring
AEMR	action effectiveness monitoring and research
AIF	Adaptive Implementation Framework
AMIP	Adaptive Management Implementation Plan
A/P	abundance and productivity
APPS	Authorization and Permits for Protected Species
BA	biological assessment
BMP	best management practices
BPA/Bonneville	Bonneville Power Administration
BRT	Biological Review Team (NMFS)
BWS	bypass with spill
CBP	Columbia Basin Partnership
CEERP	Columbia Estuary Ecosystem Restoration Program
CFR	code of federal regulations
CFS	cubic feet per second
CHaMP	Columbia Habitat Monitoring Protocol
CHARTs	Critical habitat analytical review teams (NMFS)
COMPASS model	Comprehensive passage model
Corps	U.S. Army Corps of Engineers
Council	Northwest Power and Conservation Council
CPUE	catch per unit effort
CR	Columbia River
CRFMP	Columbia River Fisheries Management Plan
CRITFC	Columbia River Inter-Tribal Fish Commission
CRS	Columbia River System
CSLs	California sea lions
CSS	Comparative Survival Study
CTCR	Confederated Tribes of the Colville Reservation
CWT	coded-wire-tagging
DART	data access in real time
DDT	dichlorodiphenyltrichloroethane
DEIS	Draft Environmental Impact Statement
DIP	demographically independent population
DO	dissolved oxygen
DPS	distinct population segment
DQA	Data Quality Act

ECO	Environmental Consultation Organizer
Ecology	Washington Department of Ecology
EFH	essential fish habitat
EIS	environmental impact statement
ENSO	El Niño/Southern Oscillation
EPA	Environmental Protection Agency
ERTG	Expert Regional Technical Group
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FFDRWG	Fish Facility Design Review Work Group
FIPs	Fishery Implementation Plans
FOGs	floating orifice gates
FOP	Fish Operations Plan
FPC	Fish Passage Center
FPOM	fish passage operations and maintenance
FR	Federal Register
FRM	flood risk management
FSOA	Flexible Spill Operations Agreement
GBT	gas bubble trauma
GCM	global climate model
GSI	genetic stock identification
HCP	habitat conservation plan
HGMP	Hatchery and Genetics Management Plan
HSRG	Hatchery Scientific Review Group
IAPMP	Inland Avian Predation Management Plan
ICTRT	Interior Columbia Technical Recovery Team
IDFG	Idaho Department of Fish and Game
IGF-1	insulin-like growth factor-1
IMW	intensively monitored watershed
ISAB	Independent Scientific Advisory Board
ISEMP	Interior Status and Effectiveness Monitoring Program
ITS	incidental take statement
JBS	Juvenile bypass system
km	kilometer
LCFRB	Lower Columbia Fish Recovery Board
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Partnership
LSRB	Lower Snake River Recovery Board
LSRCP	Lower Snake River Compensation Plan
LWD	large woody debris
MAF	million acre-feet

MAT	minimum abundance threshold
MCR	Middle Columbia River
mg/L	milligrams per liter
MIP	minimum irrigation pool
mm	millimeter
MMPA	Marine Mammal Protection Act
MOP	minimum operating pool
MPG	major population group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NGO	non-governmental organization
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPDES	National Pollutant Discharge Elimination System
NPEA	Natural Production Emphasis Area
NPMP	Northern Pikeminnow Management Program
NPT	Nez Perce Tribe
NWFSC	Northwest Fisheries Science Center
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OGAP	Oil and Grease Accountability at Operating Projects
PAHs	polycyclic aromatic hydrocarbons
PBDEs	polybrominated diphenyl ethers
PBF	physical or biological feature
PBT	persistent bioaccumulative toxics
PCBs	polychlorinated biphenyls
PCEs	primary constituent elements
PCTS	Public Consultation Tracking System
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fisheries Management Council
pHOS	proportion of hatchery-origin fish on spawning grounds
PIT	passive integrated transponder
PNI	proportionate natural influence
pNOB	proportion of natural-origin fish in broodstock
PTAGIS	Passive Integrated Transponder Information System
QET	quasi-extinction risk threshold
RCP	Representative Concentration Pathway
Reclamation/USBR	U.S. Bureau of Reclamation

RIOG	Regional Implementation Oversight Group
RM	river mile
RM&E	research, monitoring, and evaluation
RPA	Reasonable and Prudent Alternative
R/S	returns-per spawner
RSW	removable spillway weir
SARs	smolt-to-adult returns
SCT	Systems Configuration Team
S/D	spatial structure and diversity
SLEDs	sea lion excluder devices
SMP	Smolt Monitoring Program
SR	Snake River
SRB	Snake River Basin
SRKWs	Southern Resident killer whales
SSL	Steller sea lions
SST	Sea Surface Temperature
T:B	transport-bypass ratio
TAC	Technical Advisory Committee
TDG	total dissolved gas
THSC	Tributary Habitat Steering Committee
TIR	transport in-river ratio
TMDL	total maximum daily load
TMT	technical management team
TRMP	Tribal Resource Management Plan
TRT	technical recovery team
TTT	Tributary Technical Team
UCR	Upper Columbia River
UCRTT	Upper Columbia Regional Technical Team
UCSRB	Upper Columbia Salmon Recovery Board
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
UWR	Upper Willamette River
VarQ	Variable discharge
VSP	viable salmonid population
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
W/LC TRT	Willamette/Lower Columbia Technical Recovery Team
WQT	Water Quality Team

1. Introduction

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 *et seq*.), and implementing regulations at 50 Code of Federal Regulations (CFR) 402, as amended.

We also completed an essential fish habitat (EFH) consultation on the proposed action in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 *et seq*.), and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within 2 weeks at the National Oceanic and Atmospheric Administration (NOAA) Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the NMFS office in Portland, Oregon.

1.2 Consultation History

1.2.1 Consultation Before 2014

Shortly after Snake River (SR) spring/summer Chinook salmon, fall Chinook salmon, and sockeye salmon were listed under the ESA in the early 1990s, the U.S. Army Corps of Engineers (Corps), U.S. Bureau of Reclamation (Reclamation or USBR), and U.S. Department of Energy—Bonneville Power Administration (BPA), collectively referred to as the Action Agencies, began consulting with NMFS on the operation of the Federal Columbia River System (CRS[1]).[2] The litigation history related to NMFS' CRS biological opinions since that time is extensive and is not repeated here except as necessary to provide context for the current consultation.

On May 5, 2008, following 2 years of collaboration by NMFS and the Action Agencies with regional states and tribes to develop items to be included in the proposed action, and to clarify policy issues and to reach agreement or narrow areas of disagreement on scientific and technical information, as directed by Judge James Redden's remand order, NMFS issued a 2008 biological opinion.[3] The 2008 biological opinion included a Reasonable and Prudent Alternative (RPA) with 73 actions (and many more sub-actions) to be implemented over a 10-year period. In 2009, the newly inaugurated Obama Administration reviewed the 2008 biological opinion. The result of this review was a jointly developed Adaptive Management Implementation Plan (AMIP), proposed by the Action Agencies and endorsed by NMFS. On May 20, 2010, NMFS issued a supplemental biological opinion,[4] which incorporated and integrated the AMIP into the 2008 biological opinion's RPA. In 2011, the court remanded the 2010 supplemental biological opinion. On remand, the Action Agencies worked with regional implementation partners to identify habitat mitigation projects for the remaining duration of the biological opinion. Further consultation on remand culminated in NMFS' issuance of another supplemental biological

[1] In earlier biological opinions, the CRS was referred to as the Federal Columbia River Power System or FCRPS.

[2] Biological opinions issued by NMFS related to the operation of the CRS include: 1) 1992 Operation of the FCRPS (April 10, 1992); 2) Operation of the FCRPS January Through April 1993 (February 24, 1993); 3) 1993 Operation of the FCRPS (May 26, 1993); 4) 1994–1998 Operation of the FCRPS (March 16, 1994); 5) Reinitiation of Consultation on 1994–98 Operation of the FCRPS and Juvenile Transportation Program in 1995 and Future Years (March 2, 1995); 6) Supplemental FCRPS Biological Opinion (May 14, 1998) [to consider newly listed steelhead species]; 7) Supplemental Biological Opinion—Bureau of Reclamation Operations and Maintenance of its Projects in the Snake River Basin above Lower Granite Dam: A Supplement to the Biological Opinion Signed on March 2, 1995, and May 14, 1998 (December 9, 1999) [to consider Reclamation's planned operation to comply with the 1995 RPA prescription to deliver 427,000 acre-feet of upper Snake River water and the operation of all USBR projects in the Snake River upstream of Lower Granite Dam]; 8) Supplemental Biological Opinion—Operation of the Federal Columbia River Power System Including the Juvenile Fish Transportation Program: A Supplement to the Biological Opinions Signed on March 2, 1995, and May 14, 1998, for the Same Projects (February 4, 2000) [to consider six species listed as threatened or endangered in March 1999]; 9) Biological Opinion—Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin (December 21, 2000); and 10) Endangered Species Act—Section 7 Consultation Biological Opinion: Consultation on Remand for Operation of the Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia Basin (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)) (November 30, 2004).

[3] Endangered Species Act Section 7(a)(2) Consultation Biological Opinion And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)) (May 5, 2008).

[4] Endangered Species Act Section 7(a)(2) Consultation Supplemental Biological Opinion Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program (May 20, 2010).

opinion5 on January 17, 2014, which: 1) addressed specific issues raised by Judge Redden (most notably the failure "to identify specific mitigation plans beyond 2013, that are reasonably certain to occur"), 2) considered effects to newly designated critical habitat for eulachon and green sturgeon and to proposed critical habitat for Lower Columbia River (LCR) coho salmon, and 3) revised the 2008/2010 RPAs to address updated scientific information.

1.2.2 2014 Biological Opinion Litigation and Orders

On May 4, 2016, the U.S. District Court for the District of Oregon issued an opinion and order invalidating NMFS' 2008/2014 biological opinion. *Nat'l Wildlife Fed'n v. Nat'l Marine Fisheries Serv.*, 184 F. Supp. 3d 861 (D. Or. 2016). Among other rulings, the summary judgment opinion addressed NMFS' interpretation and application of the substantive standards contained in section 7(a)(2) of the ESA, 16 U.S.C. § 1536(a)(2).

In the 2008/2014 biological opinion, NMFS began with the jeopardy and adverse modification standards and analytical framework adopted in the 2000 Federal Columbia River Power System (FCRPS) biological opinion, and NMFS then addressed the legal deficiencies the court identified in the 2000 biological opinion's standards and analysis. In the 2008/2014 biological opinion, NMFS articulated the standard as involving consideration of "(a) whether the species can be expected to survive with an adequate potential for recovery (e.g., trending toward recovery) under the effects of the action, the effects of the environmental baseline, and any cumulative effects; and (b) whether affected designated critical habitat is likely to remain functional (or retain the ability to become functional) to serve the intended conservation role for the species in the near and long term under the effects of the action, environmental baseline, and any cumulative effects."

Regarding the jeopardy analysis, NMFS' 2008/2014 biological opinion used both qualitative and quantitative population-level analyses that were supplemented by qualitative analyses at the major population group (MPG) and species (evolutionarily significant unit [ESU], or distinct population segment [DPS]) level. At the population level, NMFS' analyses considered whether, with the proposed RPA actions, the populations are expected to replace themselves and grow over time (e.g., population trend metrics over 1.0). Where evidence showed that the RPA actions, combined with all other factors affecting the species, are improving the status and trends of enough populations within an MPG and ESU and, thus, contributing to their recovery, NMFS could be assured that the RPA actions were not, at the same time, jeopardizing the continued existence of the listed species. Our intent in the 2000 and 2008/2014 biological opinions, therefore, was to adopt standards that provided ample assurances that the ESA's section 7(a)(2) jeopardy prohibition was not violated. We did not find or conclude that the 2000 or 2008/2014 biological opinion standards and analyses were required by the plain language of the ESA, or our implementing regulations.

[5] Endangered Species Act Section 7(a)(2) Supplemental Biological Opinion: Consultation on Remand for Operation of the Federal Columbia River Power System (January 17, 2014).

On review, the courts overturned NMFS' 2000 and 2008/2014 biological opinions. In 2016, the district court determined that the 2008/2014 biological opinion's standards and analyses were arbitrary and capricious and did not comply with the ESA. The courts thus overturned standards and analyses that NMFS developed specifically for the CRS.

In 2018, the Action Agencies initiated consultation on CRS operational and non-operational measures, including mainstem dam operations consistent with the 2019 to 2021 Spill Operation Agreement. This agreement, signed by the states of Washington and Oregon, the Nez Perce Tribe, and the Federal Action Agencies, established a flexible spill operation intended to: 1) provide fish benefits (increasing spill levels to improve juvenile passage conditions and survival rates and adult returns), 2) provide Federal power system benefits, and 3) provide operational flexibility. The proposed action was expected to continue until a new action was adopted through the Records of Decision in the ongoing CRS Operations National Environmental Policy Act (NEPA) process. NMFS issued a biological opinion on March 29, 2019.

Rather than continue on the path of developing CRS-specific standards, in the 2019 CRS biological opinion we returned to our usual practice applied in most (if not all) ESA consultations. Specifically, we applied the statutory language and our long-standing interpretations of section 7(a)(2) that are contained in the U.S. Fish and Wildlife Services' (USFWS) and NMFS' joint consultation regulations and preambles to those regulations. In the 2019 CRS biological opinion we used those standards and long-standing interpretations of the ESA to determine whether the proposed action was likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat, and concluded it was not (NMFS 2019a).

1.2.3 2020 Consultation

On January 23, 2020, the Action Agencies requested initiation of formal consultation with NMFS under Section 7(a)(2) of the ESA, and submitted a biological assessment (BA) (BPA et al. 2020). The BA included a description of the Federal action, including how the hydropower system would be operated. On April 1, 2020, the Action Agencies provided NMFS with a letter clarifying several aspects of the proposed action and providing additional information (USACE 2020).

In this consultation, NMFS considers the effects of the Action Agencies' proposed action (the continued operation and maintenance of the CRS dams; tributary and estuary habitat mitigation programs; conservation and safety net hatchery programs; predator management programs; and research, monitoring, and evaluation [RME] programs) on eight species of salmon (ESUs), five species of steelhead (DPSs), and the Southern DPS of Pacific Eulachon and their designated critical habitat. This consultation also considers the Action Agencies' request for NMFS' concurrence on their Not Likely to Adversely Affect determinations for the Southern DPS of North American green sturgeon and the DPS of Southern Resident killer whales (SRKWs).

This opinion includes both a jeopardy analysis and a destruction or adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). NMFS does not interpret the statute or its regulations to require the proposed action to improve or increase the likelihood of survival and recovery. Section 7(a)(2) focuses on the "continued existence" of the species, not an improvement in the likelihood of recovery or the attainment of an improved status, which is addressed through section 4 recovery plans. Similarly, this opinion relies upon the regulatory definition of "destruction or adverse modification," which means "a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species (50 CFR 402.02).

On July 25, 2018, NMFS and USFWS proposed revisions to the regulations at 50 CFR Part 402 implementing section 7 of the ESA (83 FR 35178). On August 27, 2019, NMFS and USFWS published a final rule incorporating changes to the regulations. (84 FR 44976). This opinion applies those revised regulations. The jeopardy and destruction or adverse modification analyses in this opinion, also adhere to the interpretations of the ESA and its implementing regulations found in the preambles and responses to comments of the proposed and final rules referenced above.

As discussed in the proposed and final rules, the definitions of "destruction or adverse modification" and "jeopardize the continued existence of" both use the term "appreciably," and the analysis must always consider whether impacts are "appreciable," even where critical habitat or a species already faces severe threats prior to the action. There is no existing status of being "in jeopardy," "in peril," or "jeopardized" by baseline conditions, such that any additional adverse impacts must be found to meet the regulatory standards for "jeopardize the continued existence of" or "destruction or adverse modification." The terms "jeopardize the continued existence of" and "destruction or adverse modification" are, in the plain language of section 7(a)(2), determinations that are made about the effects of Federal actions. They are not determinations made about the environmental baseline for the proposed action or about the pre-action condition of the species. Similarly, NMFS is not required to identify a "tipping point" beyond which the species cannot recover from any additional adverse effect, or recovery benchmarks in making section 7(a)(2) determinations.

Additional description of our analytical approach can be found in Section 2.

1.3 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02).

This consultation evaluates the effects of an ongoing Federal action: the operation, maintenance, and management of the 14 Federal dam and reservoir projects in the CRS that are managed as a coordinated system for multiple congressionally authorized public purposes by the Action Agencies (BPA et al. 2020). The proposed action includes operational measures (e.g., flood risk management (FRM), navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions, and RME programs) for a 15-year period. The proposed action presented in the BA is summarized here.

The Corps operates and maintains 12 of the 14 Federal CRS projects: Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Dworshak, Chief Joseph, Albeni Falls, and Libby Dams. The Corps operates and maintains these projects for FRM, navigation, hydropower generation, fish and wildlife conservation, irrigation, recreation, water quality, and municipal and industrial water supply, though not every project is authorized for every one of these purposes.

Reclamation operates and maintains the remaining two of the 14 Federal CRS projects: Grand Coulee and Hungry Horse Dams. Reclamation operates these projects to support multiple legally mandated authorizations, including irrigation, hydropower generation, FRM, navigation, and municipal and industrial water supply.

BPA markets and distributes power generated at these 14 Federal projects on the Columbia River and its tributaries. Transmission facilities owned and operated by BPA interconnect and integrate electric power generated at the Federal projects to the regional transmission grid.

The Action Agencies also fund or implement substantial mitigation, enhancement, and RME programs. These programs include salmon and steelhead hatchery programs, Kootenai River white sturgeon hatchery programs, tributary habitat and estuary habitat restoration programs, predator management programs, and RME programs (including fish status monitoring).

Additional specificity and a more detailed description of the proposed action can be found in the BA (BPA et al. 2020) and in the associated BA clarification letter (USACE 2020). The BA, and associated clarification letter, are hereby incorporated by reference.

1.3.1 System Operations and Maintenance for Congressionally Authorized Project Purposes

The Action Agencies propose to continue operating and maintaining the 14 Federal CRS projects to meet congressionally authorized purposes: FRM, fish and wildlife conservation, power system management, irrigation/water supply, navigation, recreation, system maintenance, water quality, and municipal and industrial water supply, though not every project is authorized for every one of these purposes.

1.3.1.1 Operations for Flood Risk Management

The Action Agencies propose to continue operating the CRS storage projects for local FRM objectives in some locations and as a coordinated system to meet regional FRM objectives to protect life and property by minimizing flood consequences or risk of damages, regardless of the conditions presented in any given water year. CRS storage projects include Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak; John Day Dam has some limited storage space but generally is operated as a run-of-river project. Operations for these projects are developed collaboratively by Action Agency water managers and are described in the Water Control Manual for most projects. Coordinated operation of these projects for FRM can best be described in terms of seasonal operations.

1.3.1.1.1 Fall Operation: September to December

Fall operations (September to December period) at specific water storage projects are affected by a variety of factors, but projects generally are operated to reach end-of-December target reservoir elevations to create flood storage space, which usually results in operations to lower (draft) reservoir levels during this period. Operational purposes other than FRM may bring reservoir levels lower than the end-of-December FRM requirements. Grand Coulee (Lake Roosevelt) does not have a fall FRM requirement.

1.3.1.1.2 Storage Evacuation Operation: January to April

During the January to April period, the CRS storage projects operate to the storage reservation diagram (SRD) unique to each dam. The SRDs determine the maximum allowable elevation, or required minimum storage space, for each reservoir based on a given water supply forecast. Water supply forecasts at locations in the basin used to determine FRM space requirements are updated monthly from January through April (within the first 10 days of the month). Every year, the Federal storage reservoirs are operated to maximize available water for fish during the migration season, while also ensuring that FRM objectives are met.

One of the analytical tools used to determine whether a storage reservoir can be drafted during the winter and maintain a high probability of meeting project refill objectives is development of a Variable Draft Limit. Grand Coulee and Hungry Horse currently use Variable Draft Limits. A Variable Draft Limit will be developed for Dworshak Reservoir to help inform water management decisions during the months of January through March. The concept is to increase the use of the reservoir for power generation during winters with high runoff forecasts and avoid drafting the reservoir during the spring months at rates that would produce total dissolved gas (TDG) levels that would pose a risk to fall Chinook redds in the Clearwater River.

1.3.1.1.3 Refill Operation: May to July

During the May to July period, the CRS storage projects are operated to target refill, limited by system and local FRM guidance. The projects on the Columbia River operate together to meet the initial controlled flow at The Dalles Dam, while refilling reservoirs during the refill period. The initial controlled flow is a calculated flow, used in conjunction with the forecasts and available reservoir storage, to determine when to start refill to ensure a high probability of achieving total refill while managing flood risks. The probability of achieving total refill varies by project and timing, ranging from 75 to 95 percent. During the refill period, the outflow from the reservoir is kept lower than the inflow to the reservoir, allowing the water level in the reservoir to reach its targeted refill elevation when the risk of flooding has decreased significantly.

1.3.1.1.4 Proposed Changes to Storage Project Operations

The proposed changes to storage project operations consist of the following:

- Hungry Horse Dam:
    - A new sliding scale for drafting will be implemented at Hungry Horse Dam. The Corps and Reclamation will determine the summer draft from the Hungry Horse project for the purposes of delivering flow augmentation for downstream fish based on a local water supply forecast. Additionally, this modified elevation objective would be incrementally adjusted over a range of water supply conditions. These changes would allow water managers to balance local resident fish priorities in the upper basin with downstream flow augmentation for the Columbia River downstream of Chief Joseph Dam.
- Libby Dam:
    - Similar to Hungry Horse Dam, a new sliding scale for drafting is included in the proposed action for implementation at Libby Dam. Refer to the bullet above for details.
    - The proposed action would modify draft rates at Libby Dam to provide water managers more flexibility to incorporate local conditions in the upper basin and alter flow management so that local flood durations and start of refill operations are tied to Kootenai Basin runoff. Draft targets remain the same as current operations in December and for forecasts greater than 6.9 million acre-feet (MAF) at Libby Dam. During refill (generally April/May to July), the VarQ[6] refill flow calculation will be adjusted to real-time local water conditions and account for planned releases, such as the sturgeon volume release. Implementing this action would improve water management flexibility to respond to local FRM conditions in the upper basin. It would also provide greater flexibility to provide suitable temperature and flow conditions to benefit resident fish.
    - The proposed action would begin influencing reservoir elevations after December 31, and its effects are best understood by looking at the spring, when the lowest reservoir elevation typically occurs. The modified draft rate at Libby Dam causes the spring

[6] VarQ (variable discharge) flood control is used at Libby and Hungry Horse dams to maintain effective flood control while providing ecosystem benefits to ESA-listed species including salmon and steelhead. In all but the wettest and driest years, VarQ adjusts reservoir drawdown in January to April in proportion to forecasted inflow, and then continuously regulates outflows in response to observed inflows. It reduces the amount of reservoir space required in the spring for flood control, resulting in a more natural spring flow regime and increasing the likelihood of full reservoirs and water supplies for summer flow needs. The Final EIS and Records of Decision from the Corps and Reclamation for VarQ operations can be accessed at https://www.usbr.gov/pn/fcrps/hydro/varq/index.html.

reservoir elevation to be lower when the seasonal water supply forecast is less than 6.9 MAF at Libby Dam, which allows the reservoir to warm more quickly. Water is released starting in mid-May (referred to as the Sturgeon Pulse) and the combination of higher flows and warmer outflow temperatures is designed to enhance spawning opportunities for Kootenai River white sturgeon. See Section 2.3.2.1 of the BA for additional details on this measure as it relates to the Sturgeon Pulse, outflows at Libby Dam, and flows at Bonners Ferry.

- Grand Coulee Dam:
  - An additional 45,000 acre-feet could be pumped from Lake Roosevelt at Grand Coulee Dam above previous operations. Additionally, this operation would change the timing of delivery of recently developed water supplies for the Odessa Subarea of the Columbia Basin Project (164,000 acre-feet for irrigation and 15,000 acre-feet for municipal and industrial users of the current supplies) from September and October to when the water is needed, on demand. The 45,000 acre-feet of water supports near-term additional development of authorized project acres. Water pumped from Lake Roosevelt would be delivered as the demand arises during the irrigation season (March to October).
  - A modified fall operation to increase flexibility for hydropower at Grand Coulee Dam is included in the proposed action. Lake Roosevelt is refilled after summer flow augmentation for the benefit of resident fish; the project typically refills through October to prepare the project for winter power operations and to support chum spawning and rearing below Bonneville Dam. The proposed action modifies the Lake Roosevelt minimum refill elevation of 1,283 feet from the end of September to the end of October to allow more operational flexibility for power generation while also meeting downstream flow objectives, including Priest Rapids minimum flows and lower Columbia River minimum flows for navigation. This proposed action may result in lower end of September Lake Roosevelt elevations when compared to previous operations, particularly in low water years. Short-term operations would continue to be coordinated with the tribes.
  - The proposed action includes a modified storage reservation diagram with a planned draft rate of 0.8 feet per day; this would not change the draft rate limit of 1.5 feet per day or the deepest FRM elevation, typically on April 30. This proposed action changes the planned timing and rate of the draft to satisfy the FRM requirements. FRM space requirements are determined by water supply forecasts and upstream storage reservoir capacity. This calculation methodology has been updated including changes to how Grand Coulee space requirements respond to changes in upstream storage. The reduced draft rate would reduce the risk of erosion along the shoreline and may reduce spill in some years. This action will maintain the same level of flood risk and allow water managers to better manage drafts for Grand Coulee Dam under a wide range of hydrologic conditions.

  - This proposed action could expedite the maintenance schedule for the power plants and spillways of the Grand Coulee project. The proposed change to maintenance operations at Grand Coulee could result in additional spill in limited situations; changes to total outflows are not expected. The maintenance on the power plants could reduce the number of generating units available, requiring additional spill in some situations. The project could keep 27 of the 40 regulating gates and/or eight drum gates in service and take the others out of service to perform spillway maintenance activities. This action could improve safety, reliability, and the capacity of power plants and spillways at Grand Coulee Dam.
- Dworshak Dam:
  - Slightly deeper reservoir drafts at Dworshak Dam would be calculated in-season to improve FRM operations, reduce spring spill at Dworshak Dam, and increase hydropower generation in January to March, when market demand is higher. These modifications would result in a reduction of non-fish passage spill in the spring, resulting in reduced TDG exposure to fish in the Clearwater River below Dworshak Dam and, in particular, fish in hatcheries downstream of the dam. This measure would be implemented in a manner to limit the risk of the reservoir not refilling later in the year. The Corps would define a rule curve through further coordination and study with BPA to operate Dworshak Dam.
- John Day Dam:
  - The proposed action would remove current restrictions on seasonal pool elevations at the John Day project in the winter, allowing more operating flexibility for hourly and daily shaping of hydropower generation. The proposed action would allow for operation of the reservoir across the full range possible, between 262.0 and 266.5 feet elevation outside of the fish passage season, except as needed for FRM. The proposed action will maintain a minimum elevation of 262.5 feet during the irrigation season.
    - The John Day Reservoir elevation will be held to deter Caspian terns from nesting in the Blalock Islands Complex during April 10 through June 1 or June 15 (see Section 1.3.1.2.5, below, for additional details).

1.3.1.2 Operations for Conservation of Fish and Wildlife

The operation of the 14 CRS projects is managed to benefit ESA-listed anadromous (e.g., salmon and steelhead) and resident species (e.g., Kootenai River white sturgeon, and bull trout), as well as other non-listed species (e.g., salmonids, burbot, and lamprey), while achieving other project purposes.

1.3.1.2.1 Storage Project Operations

The Action Agencies manage water and reservoir operations for both anadromous and resident fish using the specific operations described in detail in the proposed action. These operations consider seasonal spring and summer flow objectives for migrating juvenile salmon and steelhead at several representative locations in the Columbia and Snake Rivers, and fall and winter flows for spawning and incubating chum salmon below Bonneville Dam. While projects vary, in general, this includes the following:

- Operate Libby, Hungry Horse, Grand Coulee, and Dworshak to be at their elevation objectives in early April (the exact date to be determined during in-season management) to maximize flows for the spring out-migration of juvenile salmon.
- Refill the storage projects by the end of June/early July (exact date to be determined during in-season management) to provide summer flow augmentation consistent with available water supply, spring operations, and FRM requirements.
- Draft Libby, Hungry Horse, Grand Coulee, and Dworshak to their August 31 or September 30 elevation targets based on water-supply volume forecast to support summer flow augmentation for juvenile fall Chinook salmon migration.
- Provide fall and winter tailwater elevations/flows to support chum salmon spawning and incubation in the Ives Island area below Bonneville Dam, and to provide access for chum salmon spawning in Hamilton and Hardy Creeks.
- Balance the consideration of these priorities for various listed fish (resident and anadromous).
- The Corps and Reclamation will determine the summer draft from the Libby and Hungry Horse projects for the purposes of delivering flow augmentation for downstream fish based on a local water supply forecast. Additionally, this modified elevation objective would be incrementally adjusted over a range of water supply conditions. These changes would allow water managers to balance local resident fish priorities in the upper basin with downstream flow augmentation for the Columbia River downstream of Chief Joseph Dam.
- The proposed action would modify draft rates at Libby Dam to provide water managers more flexibility to incorporate local conditions in the upper basin and alter flow management so that local flood durations and start of refill operations are tied to Kootenai Basin runoff. Draft targets remain the same as current operations in December and for forecasts greater than 6.9 MAF at Libby Dam. During refill (generally April/May to July), the VarQ refill flow calculation will be adjusted to real-time local water conditions and account for planned releases, such as the sturgeon volume release. Implementing this action would improve water management flexibility to respond to local FRM conditions in the upper basin. It would also provide greater flexibility to provide suitable temperature and flow conditions to benefit resident fish. As this operation is implemented, adjustments to provide more space in the reservoir may be made with input from interested parties if new information emerges about nutrient flushing and temperature impacts that could not be captured with the current modeling tools.

The proposed action would begin influencing reservoir elevations after December 31, and its effects are best understood by looking at the spring, when the lowest reservoir elevation typically occurs. The modified draft rate at Libby Dam causes the spring reservoir elevation to be lower when the seasonal water supply forecast is less than 6.9 MAF at Libby Dam. A benefit of the deeper draft is to help the reservoir warm faster in the spring so that warmer water will be available for flows to benefit Kootenai River white sturgeon (the Sturgeon Pulse) that starts in mid-May.

The proposed action adjusts the refill equations for all years, which results in increased likelihood of reservoir refill in all but the lowest 5 percent of years. The change in refill shaping is most notable prior to the Sturgeon Pulse, and then again after it. The Sturgeon Pulse volume is expected to remain unchanged (i.e., from current CRS operations); it starts in mid-May and continues through sometime in June, depending on the required volume to be released. The Action Agencies estimate that the peak reservoir elevation would usually be achieved in July or early August; there would be a 4 percent increased chance of the reservoir reaching elevation 2,454 feet above mean sea level (National Geodetic Vertical Datum of 1929 or NGVD29) or higher (within 5 feet of the full pool elevation of 2,459 feet NGVD29) by July 31. In August and September, the reservoir elevation would generally be about 1 to 4 feet higher than current CRS operations.

Another purpose of this proposed action is to increase the peak refill elevation. The sliding scales at Libby and Hungry Horse Dams target a higher elevation than used in previous operations, specifically in the wettest 25 percent of years. These changes can carry over into October and November in some years.

The reservoir levels are expected to be higher in the months of July, August, and September. In July, this is attributable to the modified draft rate at Libby Dam, which tends to increase the peak refill elevation. In August, the higher reservoir levels are attributable to a combination of the modified draft at Libby Dam and sliding scale at Libby and Hungry Horse measures. In September, the higher reservoir levels are attributable to the sliding scale at Libby and Hungry Horse measure, which has fewer years drafting to 2,449 feet NGVD29) than the No Action Alternative (due to the change in forecast location), and many more years with elevations above 2,452 feet NGVD29 than the No Action Alternative (USACE et al. 2020).

- Libby Dam Outflow. The proposed action includes modified draft and refill and “sliding scale” operations at Libby Dam, which affect drafting and refill operations and have a direct effect on outflows throughout the year. Notably, in dry years water releases may be lower in late April and May and higher in June, July, and August. In wet years water releases may be higher in late April and lower in late June, July, and August. Monthly average outflow from Libby Dam in typical to dry years is expected to increase in January, February, and March, and then decrease in April and May as refill begins (caused primarily from the modified draft rate) (USACE et al. 2020, Chapter 7, Table 7-7). However, the Sturgeon Pulse volume, which happens in all but the 20 percent driest years, will remain unchanged because the reduction in outflows happens prior to the mid-May start of the Sturgeon Pulse. The Sturgeon Pulse continues through a date in June that is determined using the water supply forecast. In dry years, summer outflows are expected to be 2 to 3 thousand cubic feet per second (kcfs) higher due to the higher refill elevations resulting from the modified draft rate. After the annual Sturgeon Pulse is completed, changes in outflow occur as a result of the proposed sliding scale at Libby and Hungry Horse Dams and modified draft rate at Libby Dam (i.e., modified operations target a higher end-of-September elevation in the wettest 25 percent of years based on the Libby Dam water supply forecast).

- Bonners Ferry Flow. The proposed action would also affect flows at Bonners Ferry. In general, the flows would differ in much the same way as at Libby Dam, though to a smaller degree due to dilution effects of major tributaries downstream of the dam and effects of backwater from Kootenay Lake. The reasons for the changes seen at Bonners Ferry are the same as those described for Libby Dam outflows above (USACE et al. 2020, Chapter 7, Table 7-8).
- Grand Coulee Dam/Lake Roosevelt. Changes to operations of storage projects will result in small changes in Lake Roosevelt inflow compared to previous CRS operations. Increases in flow are more prevalent in the winter months, and decreases in flow within 1 percent may occur in the spring and summer months. The change in upstream flow accounts for much of the change seen in the Grand Coulee outflow and influences reservoir elevations at Lake Roosevelt.

The Action Agencies also propose to continue to pursue agreement with Canada, through the Columbia River Treaty, on: 1) annual agreements for flow augmentation of up to 1.0 MAF released within the May to July period, and 2) long-term Non-Treaty Storage Agreements for flow augmentation of up to 0.5 MAF released in the spring to benefit juvenile migrants. Flow augmentation pursuant to the Non-Treaty Storage Agreement would be implemented in the lowest 20th percentile of water conditions ("dry year strategy") if not used in the prior year.

1.3.1.2.2 Spring Juvenile Fish Passage Spill Operations

Spring spill operations will occur April 3 to June 20 at the four lower Snake River projects, and April 10 to June 15 at the four lower Columbia River projects or as defined in the 2020 Fish Passage Plan. Daily spill caps to meet tailrace TDG targets will be coordinated with NMFS and adjusted daily as necessary. Target spill levels for spring 2021 at each project are defined in Table 1.3-1.

The intent of the flexible spring juvenile fish passage spill operation is to: 1) provide fish benefits (increasing spill levels to improve juvenile passage conditions and survival rates and adult returns), 2) provide Federal power system benefits, 3) provide operational feasibility, and 4) evaluate the effectiveness of the spring spill operation. Spring spill levels will follow the flexible spill concept (BPA et al. 2020). Beginning in the spring of 2021, the four lower Snake River and McNary dams will all operate up to 125 percent TDG gas cap spill for a minimum of

16 hours per day, and each project may operate under "performance spill" for up to 8 hours per day. The Dalles Dam will spill to 40 percent spill. John Day Dam will spill to 120 percent TDG gas cap spill for 16 hours per day, with 32 percent spill occurring during 8 hours of performance spill. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs spill constraint) for up to 16 hours per day and 8 hours of performance spill at 100 kcfs. Typically, the 8 hours of performance spill may be split into two separate blocks or used over a consecutive period of time, not to exceed eight hours. There is one exception to this operation at Little Goose Dam. When the adult fish passage trigger of 25 spring Chinook salmon counted passing upstream of Lower Monumental Dam is met, performance spill must be implemented in the morning hours at Little Goose Dam and continue for eight consecutive hours to reduce the risk of adult Snake River spring/summer Chinook salmon passage delay. If serious adult passage impacts are observed, adaptive management processes may be employed to help address issues that may arise in-season as a result of implementing these proposed spill operations (BPA et al. 2020).

In general, performance spill blocks are intended to provide more flow through turbine units. Higher daytime powerhouse flow is intended to provide power marketing flexibility and benefit passage conditions for adult migrants that can have difficulty passing during high spill at some projects. The gas cap spill periods are intended to increase spillway passage, reduce forebay residence time, and reduce powerhouse encounter rates for downstream migrating juvenile salmonids. Attempts will be made to minimize in-season changes to the proposed spill operations, but if substantial impacts are observed (e.g., potential delays to adult migration, gas bubble trauma [GBT] above water quality agency biological thresholds for salmonids and non-salmonid fish, increased river flows, transmission reliability, spill due to lack of market, lack of turbine capacity, or effects on navigation), operations may be adjusted. The Corps will coordinate these changes and decisions through the established Regional Forum. Existing GBT monitoring and adaptive management protocols for juvenile salmon will be used to determine if GBT thresholds have been exceeded. If thresholds have been exceeded, and if river conditions allow, the Action Agencies may reduce spill, where appropriate, in accordance with Oregon[7] and Washington[8] water quality standards and implementation guidance.[9]

The process for adaptive management of the flexible spill component of the CRS operations (Adaptive Implementation Framework, or AIF) is attached to the Action Agencies' Columbia River System Operations Draft Environmental Impact Statement (DEIS) Appendix R (Part 2),

[7] The Oregon Environmental Quality Commission approved the Order Approving a Modification to the Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at the January, 24, 2020 meeting. The Order was signed on February 11, 2020 by the Oregon Department of Environmental Quality director.

[8] On July 31, 2019, Washington Department of Ecology (Ecology) proposed amendments to Chapter 173-201A Washington Administrative Code (WAC) Water Quality Standards for Surface Waters of the State of Washington (AO # 19-02). On December 30, 2019, Ecology adopted the final rule amendments. The EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii).

[9] Rule Implementation Plan—Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington. WDOE publication number: 19-10-048. December, 2019.

released on February 28, 2020, for public review and comment (USACE et al. 2020). This AIF appended to the DEIS replaced the previous draft version shared with NMFS and the U.S. Fish and Wildlife Service on January 23, 2020.

The Action Agencies propose to investigate the feasibility of native non-salmonid fish collection at the current juvenile bypass systems (JBSs) locations and the likelihood of meeting the Washington Department of Ecology (Ecology) required minimum sample size of 50 native non-salmonid fish per week and at least three species. The Action Agencies also propose to explore the practicality of secondary native non-salmonid fish collection and GBT monitoring through the Northern Pikeminnow Removal Program index sampling that currently exists downstream of a dam project where 125 percent TDG gas cap spill occurs.

The Action Agencies propose to continue GBT monitoring of juvenile salmonids using the primary established protocols. The unpaired fins and eyes will be examined for the presence of bubbles and the area covered with bubbles will be quantified at five of the CRS dams (Lower Granite, Little Goose, Lower Monumental, McNary, and Bonneville Dams). Native non-salmonid fish collected in the JBSs, or through other locations in-river or at the dam, will be monitored using the same methods applied to salmonids. The data will be reported to fisheries management entities and the water quality agencies of Washington and Oregon on a daily basis. The data will be made available to other interested parties through Fish Passage Center (FPC) weekly reports and when postings are made to the FPC web site during the season. The 2020 sampling methodologies, and the data collected, will be used to develop biological monitoring plans required for the 2021 spring spill season. This process will continue annually through the time frame of the proposed action.

Table 1.3-1. Summary of proposed spring spill levels at lower Snake and Columbia River projects.

Project	Flexible Spill (16 hours per day)[1, 2, 3, 5]	Performance Standard Spill (8 hours per day)[2, 4, 5]
Lower Granite[5]	125% Gas Cap	20 kcfs
Little Goose[6, 7]	125% Gas Cap	30%
Lower Monumental	125% Gas Cap (uniform spill pattern)	30 kcfs (bulk spill pattern[8])
Ice Harbor	125% Gas Cap	30%
McNary	125% Gas Cap	48%
John Day	120% TDG Target	32%
The Dalles[9]	40%	40%
Bonneville[10]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address serious issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility (with the exception of Little Goose and Lower Granite operations described in the notes that follow). Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current minimum operating pool (MOP) assumptions, except as noted below.

[5] Lower Granite Exception One - If adult passage delays are observed at Lower Granite Dam, the Corps may implement performance standard spill at Lower Granite Dam for at least 4 hours in the AM (beginning near dawn). Implementation of this modification may also trigger in-season reevaluation of options to balance power principle.

[6] Little Goose Exception One - As soon as practicable (and, in any event, no more than 24 hours) after a cumulative total of 25 adult spring Chinook salmon (not including jacks) pass Lower Monumental Dam, operate Little Goose spill at 30 percent spill for 8 consecutive am hours (April 1 to 15, start at 5 AM; April 16 to June 20, start at 4 AM).

[7] Little Goose Exception Two - During periods of involuntary spill, spill at 30 percent for 8 hours/day during the hours described in footnote 6 above and store additional inflows that exceed hydraulic capacity in the forebay above MOP if necessary. When it is necessary to pond water to achieve the lower spill levels due to high inflow, water stored above MOP should be drafted out over the remaining hours by increasing spill to pass inflow from 1200 to 1600 hours (or 1300 to 1700 hours from April 3 to 15), then increasing spill as necessary from 1600 to 0400 (or 1700 to 0500 hours from April 3 to 15) to draft the pool back to MOP. If it is forecast that the drafting spill will generate TDG levels in the tailrace in excess of 130 percent TDG, use all 16 hours to return the pool to MOP.

[8] If the specified spill level at bulk pattern exceeds the gas cap, then spill pattern will be changed to uniform.

[9] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[10] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

1.3.1.2.3 Summer Juvenile Fish Passage Spill Operations

Summer spill operations will occur from June 21 to August 31 at the four lower Snake River projects, and June 16 to August 31 at the four lower Columbia River projects or as defined in the annually updated Fish Passage Plan. The proposed action states that summer spill will be divided into two periods, an initial summer spill period occurring from the end of spring spill until August 14, and a late summer spill period that begins on August 15 and ends on August 31st (BPA et al. 2020). Target summer spill levels at each project are defined in Table 1.3-2.

Table 1.3-2. Summary of proposed summer target spill levels at lower Snake and lower Columbia River projects.

Project	Initial Summer Spill Operation	Late Summer Transition Spill Operation (August 15 to August 31)
Lower Granite	18 kcfs	Removable Spillway Weir or 7 kcfs
Little Goose	30%	Adjustable Spillway Weir or 7 kcfs
Lower Monumental	17 kcfs	Removable Spillway Weir or 7 kcfs
Ice Harbor	30%	Removable Spillway Weir or 8.5 kcfs
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs

1.3.1.2.4 Reservoir Operations

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at minimum operating pool (MOP) with a 1.5-foot operating range from April 3 until August 14 unless adjusted on occasion to meet authorized project purposes, primarily navigation (Table 1.3-3). Except for the John Day project, the lower Columbia River projects (Bonneville, The Dalles, and McNary) will be operated at normal operating range for each project.

From April 10 to June 1 (or as feasible based on river flows), the John Day Reservoir elevation will be held between 264.5 and 266.5 feet to deter Caspian terns from nesting in the Blalock Islands Complex during this period. The Action Agencies intend to begin increasing the forebay elevation prior to initiation of nesting by Caspian terns to avoid take of tern eggs; operations may begin earlier than April 10 (when the reservoir is typically operated between 262.0 and 266.5 feet). The operation will be adaptively managed due to changing run timing; however, the intent is to begin returning the elevation of John Day Reservoir to MIP (262.5 to 264.5 feet) on June 1 (but no later than June 15) and to maintain it in that range through August 31. The higher reservoir elevation is planned for the period when about 95 percent of the juvenile steelhead migration will have passed John Day Dam based on historical information. The results of this action will be monitored and communicated with USFWS and NMFS in the appropriate forums (i.e., Technical Management Team [TMT]; Fish Passage Operations and Maintenance [FPOM], a forum that includes NMFS Fisheries, USFWS, and regional partners; and Studies Review Work Group [SRWG]). During the operation, safety-related restrictions will continue, including, but not limited to, maintaining ramp rates for minimizing project erosion and maintaining power grid reliability.

The proposed action will remove current restrictions on seasonal pool elevations at the John Day project in the winter, allowing more operating flexibility for hourly and daily shaping of hydropower generation. The proposed action will allow for operation of the reservoir across the full range possible, between 262.0 and 266.5 feet elevation outside of fish passage season, except as needed for FRM. The proposed action will maintain a minimum elevation of 262.5 feet during the irrigation season, generally March 15 through November 15.

Table 1.3-3. Minimum operating pool (MOP), Minimum Irrigation Pool (MIP), and Normal Operating Elevation Range for CRS projects[1].

Project	Normal Operating Elevation Range		1.5-foot MOP/ 2.0-foot MIP Restricted Elevation Range	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Lower Granite[2]	733.0	738.0	733.0	734.5
Little Goose[3]	633.0	638.0	633.0	634.5
Lower Monumental[3]	537.0	540.0	537.0	538.5
Ice Harbor[3]	437.0	440.0	437.0	438.5
McNary[4]	337.0	340.0	N/A	N/A
John Day	262.0	266.5	262.5	264.5
The Dalles[4]	155.0	160.0	N/A	N/A
Bonneville[4]	71.5	76.5	N/A	N/A

[1] MOP elevations provided in feet above mean sea level (NGVD29).

[2] Due to sedimentation near the Port of Clarkston, Lower Granite Reservoir may require variable MOP operations relative to river flow as needed for navigation as described in the FOP.

[3] Little Goose, Lower Monumental, and Ice Harbor may have adjusted MOP for navigation (Raised MOP or Expanded MOP), as described in the FOP.

[4] McNary, The Dalles, and Bonneville Dams have no MOP or MIP restriction and operate within normal elevation range. Normal operation range differs from minimum and full pool primarily due to navigation constraints (Wright 2019).

1.3.1.2.5 Transport Operations

The start of juvenile transport operations at Lower Granite, Little Goose, and Lower Monumental Dams will target April 24 (collection starting on April 23), but may start as early as April 15. Prior to the year 2018, juvenile transport generally began on May 1. The proposed earlier transport date is intended to provide additional flexibility to adjust to earlier juvenile migration timing, increase transport rates for spring migrants (which would otherwise decrease substantially as a result of the proposed flexible spill operations), and evaluate the value of transporting fish earlier in the season. The decision on when to initiate transport will be made annually and will be coordinated through the TMT and the Regional Implementation Oversight Group, but transport will begin no later than May 1. This is consistent with operations in 2018-2020, when transport began on April 24. In 2020. Transport operations will continue through the end of October at Lower Granite and Little Goose Dams and through the end of September at Lower Monumental Dam, regardless of when summer spill operations end. As part of ongoing discussions between parties of the 2019 to 2021 Flexible Spill Operation Agreement, cessation of transport operations between June 21 and August 15 may occur. Additionally, allowances for adaptive management through established regional forum processes may lead to further modifications to the transport program.

1.3.1.3 Operations for Power System Management

The Action Agencies propose to continue operating the 14 Federal CRS projects to generate electricity to meet regional load (demand). Power will be generated to meet the daily and seasonal demand for electricity, using any remaining flexibility to manage water flow.[10] This includes balancing electricity demand and supply, managing the system to address or avoid emergencies, and integrating renewable resources. BPA must also manage and provide operating reserves based on required reserve obligations using dispatchable energy generation[11] to ensure that generation within the balancing authority area matches load at all times through the deployment of balancing reserves, and maintains the safety and reliability of the transmission grid by dispatching contingency reserves during unplanned, emergency events (e.g., failed generator event). See the BA (BPA et al. 2020), Section 2.3.3, and the April 2020 clarification letter for more details (USACE 2020).

1.3.1.3.1 Fall Operational Flexibility for Hydropower

The proposed action modifies the Lake Roosevelt minimum refill elevation of 1,283 feet from the end of September to the end of October to allow more operational flexibility for power generation while also meeting downstream flow objectives, including Priest Rapids minimum flows and lower Columbia River minimum flows for navigation. This proposed action may result in lower Lake Roosevelt elevations at the end of September. Based on 80 years of historical records and modeling results, the end of September elevation was below 1,283 feet in approximately 40 percent of years, and in October the elevation is projected to be below 1,283

[10] The Action Agencies generally prioritize FRM and environmental responsibilities, such as conservation actions for protected fish species, which limits flexibility to meet daily and seasonal demand for electricity.

[11] Dispatchable generation refers to sources of electricity that can be dispatched (generation is increased or decreased) at the request of power grid operators or of the plant owner to meet fluctuations in demand or supply. Often, baseload power plants, such as nuclear or coal, cannot be turned on and off in less than several hours. The time periods in which a dispatchable generation plant may be turned on or off may vary in time frames of seconds, minutes or hours.

feet in approximately 10 percent of the years. For comparison, under the previous operation, the reservoir elevation was modeled to be at or above 1,283 feet by the end of September each year; however, during dry years refilling to this elevation impacted power generation flexibility. Short-term operations would continue to be coordinated with the tribes.

1.3.1.3.2 Turbine Operations Above ±1 percent Peak Efficiency Range

As one component of the proposed action, the Action Agencies will have the flexibility to operate turbines above the ±1 percent of peak efficiency range at all 14 dams, including the four lower Snake River and four lower Columbia River dams. Generally, for power, the best operating range for turbines is within ±1 percent of peak efficiency, where the most power is produced for a given volume of water; however, there are some conditions that can be advantageous to operate at higher levels. This element of the proposed action would occur under limited conditions, frequencies, and durations to provide grid reliability, flexibility to incorporate other resources (such as wind, solar power, other hydropower projects, gas, coal, and nuclear power), and additional power generation when demand and market is available.

During the months of April to August, the Action Agencies intend to meet all required fish passage spill operations (beginning April 3 on the lower Snake River and April 10 on the lower Columbia River or as described in the Fish Passage Plan), before operating turbines above the 1 percent efficiency range, as described in the BA (BPA et al. 2020). During spring and summer fish passage, the Action Agencies will operate units within 1 percent peak efficiency except when units are operated above 1 percent peak efficiency under limited conditions and durations to provide grid reliability, flexibility to incorporate other resources (such as wind, solar, other hydro projects, gas, coal, and nuclear), and additional power generation when demand and market are available (USACE 2020). Action Agencies will continue to assemble project-specific summaries on a monthly basis. These summaries will report incidences where operations exceed ±1 percent of peak efficiency range, as outlined in Appendix C of the Fish Passage Plan (reporting requirements in Section 5, Quality Control). During the rest of the year, September 1 to April 3 on the lower Snake River and April 10 on the lower Columbia River, the same soft constraints will be implemented; however, turbines may also be operated within normal range (including above and below 1 percent peak efficiency range).

- **Contingency reserves** will be used to meet energy demands caused by unexpected events such as transmission interruption or failure of a generator. The exact timing, magnitude, and location of the need to deploy contingency reserves cannot be predicted, which makes pre-coordination for each individual event impossible. These events are rare and, when they occur, Action Agency system operators will strive to cover the contingencies without temporarily operating above the ±1 percent of peak efficiency range. On average, contingency reserves at each project are estimated to be deployed once per month for up to 35 minutes and are limited in duration (not to exceed 90 minutes). Carrying contingency reserves above the 1 percent peak efficiency range would provide operating flexibility, and if an event is large enough to require action for greater than 90 minutes (e.g., loss of generation from a nuclear plant), BPA will find other tools to maintain grid reliability. As currently defined in the Fish Passage Plan, Appendix C, any operations above ±1 percent of peak efficiency range that are deployed per project for contingency reserves will be reported.

- During periods of high spring run-off, which may result in TDG production above targeted levels of 125 percent saturation, the Action Agencies may operate turbines above the ±1 percent of peak efficiency range to mitigate for TDG. The purpose of mitigating TDG production is to reduce the duration and magnitude of water quality standards exceedances in the tailraces of each project due to lack of load, lack of turbine capacity spill levels at high river flow levels. While TDG management may occur at lower flows, if there are a high number of turbine outages, the proposed action would occur when minimum flow levels reach 160 kcfs on the lower Snake River and 340 kcfs on the lower Columbia River. During these high flow conditions, the Action Agencies intend to operate all available turbines before exceeding the upper ±1 percent of peak efficiency range.
- The Action Agencies will coordinate with the Regional Forum, in this case the FPOM, to implement a priority list of TDG mitigation operations by project. Coordination will aid in the development of a prioritized operation that minimizes negative impacts to fish and considers fish condition and survival metrics, gatewell hydraulics, unit design, and project capacity. As currently defined in the Fish Passage Plan, Appendix C, any operations above ±1 percent of peak efficiency range that are deployed per project for TDG mitigation will be reported.
- BPA is responsible for CRS grid reliability, which requires the use of balancing reserves to follow sub-hourly power demand and supply fluctuations. Because supply must equal demand for power second-by-second, power generation must increase and decrease automatically as demand for power changes. Furthermore, to integrate the use of other renewable power sources, balancing reserves assist in compensating for within-hour changes (e.g., due to changes in wind and solar availability). More specifically, BPA assigns a share of balancing reserves to Grand Coulee, Chief Joseph, and each of the four lower Snake and four lower Columbia projects according to the amount of operating flexibility each project has for the prevailing water conditions.
- To meet expected power demand, an hourly basepoint of target megawatts (MW) is allocated to available generating units at each project. If actual within-hour generation is different from the set basepoint, then the project deploys reserves to either increase generation (deploy reserves upward) or decrease generation (deploy reserves downward) to preserve the balance of supply and demand. Basepoint departures would have increased risk of generating above ±1 percent of peak efficiency range if the basepoint was set near the upper 1 percent limit. Flow thresholds must be met and a positive market present (i.e., net demand for power) to acquire enough load to set a basepoint near the upper 1 percent limit. During these high flow conditions, the Action Agencies intend to operate all available turbines before exceeding the upper ±1 percent of peak efficiency range.

> As part of the proposed action, BPA intends to set all hourly basepoints for expected power demand within ±1 percent of peak turbine efficiency at the lower Snake and Columbia River dams. The application of balancing reserves across multiple, and up to all eight, projects is expected to result in a reduction in magnitude of departures from basepoint within each hour. The Action Agencies anticipate that this proposed operation will result in a frequency and magnitude of events that, on average, does not exceed 30 hours per month, per project. Actual use of the proposed action is expected to be lower with the application of basepoint restrictions within ±1 percent of peak efficiency ranges (over 50 percent of the time balancing reserves would be below the upper ±1 percent of peak efficiency). Additionally, flow thresholds must be met and a positive market present to acquire enough load to set a basepoint near the upper 1 percent; during high flow conditions, markets can be negative, and therefore BPA would not want to operate the turbines above ±1 percent of peak efficiency ranges.

BPA will continue to assemble and provide monthly summaries of project-specific excursions from ±1 percent of peak efficiency operating ranges to the Corps, as outlined in Appendix C of the Fish Passage Plan (reporting requirements in Section 5, Quality Control). The Corps will continue to provide annual reports to NMFS of reportable excursions from ±1 percent operating range during fish passage season, which include codes associated with excursions (e.g., code 13, TDG reduction, and code 7, emergency conditions or system failures associated with system reliability for contingency reserves) (Appendix C, Table C-1 of the Fish Passage Plan). After 3 years of the proposed operation, the Action Agencies will produce a summary of frequency and duration of operations that occurred above ±1 percent of peak efficiency turbine operating range by project during spring and summer spill operations (as prescribed in Appendix C of the Fish Passage Plan) and will coordinate with the Services on future operations.

1.3.1.3.3 Extension of Zero Generation Operations

In the Pacific Northwest, energy demands have typically peaked in the wintertime as the need for heating increases, and ensuring a sufficient supply of electricity in the winter can be a challenge, particularly when demand increases dramatically region-wide and little or no electricity is available in the wholesale market during cold temperature events. Because most renewable resources generate power when the wind blows or the sun shines, regardless of when residents and businesses in the Northwest need the electricity, other generators (typically hydropower and gas-fired power plants) must adjust their power generation to compensate for fluctuations in energy produced by these variable resources (i.e., to integrate the renewable power sources). Within normal operating limits and other project requirements, BPA uses the capacity of the CRS projects to support the integration of these additional carbon-free energy resources into the regional and western electrical grid. This ancillary service provided by the CRS is becoming increasingly important as more wind and solar power sources come online in the Pacific Northwest. A key component of how wind and solar power resources are integrated into the CRS is the flexibility to cease power generation when there is little demand.

Between October 15 and February 28, when power market conditions warrant and when river conditions make it feasible, power generation at Snake River projects may cease, and water stored, during nighttime hours, most commonly implemented between 2300 and 0500 hours when demand for power is lowest or other renewable resources are generating surplus power (or both). This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation will be part of the proposed action. This shift in current operation would allow operators to save water in low demand periods to use for hydropower generation during higher demand periods. The timing and need for ceasing power generation during this period is difficult to predict. However, based on previous operations between December 15 and February 28 and during nighttime hours only, BPA estimates that the use of this operation may occur 1 out of every 3 to 5 days at each project. See the BA (BPA et al. 2020) and water management plan for additional details.

1.3.1.4 Operations for Irrigation/Water Supply

Reclamation and the Corps propose to continue to store and divert water for irrigation and water supply (see the BA, Section 2.3.5, for more details [BPA et al. 2020]). This includes the operation of the Columbia Basin Project and the mainstem hydrologic effects of several Reclamation irrigation projects that are not coordinated with the CRS (The Dalles project, Chief Joseph Dam project, Umatilla projects, including phase I and phase II; Yakima project; Deschutes project, and Crooked River project are included in this consultation). Depletions from these non-CRS irrigation projects are included in the Columbia River hydrologic models for the CRS.

Also included in the modeling is the Lake Roosevelt Incremental Storage Release Project, a component of the Columbia River Water Management Program. The proposed action intends to use this program to improve municipal and industrial water supply, provide water to replace some groundwater use in the Odessa Subarea, enhance stream flows in the Columbia River to benefit fish, and provide water to interruptible water right holders in drought years. The Lake Roosevelt Incremental Storage Release Project does not reduce flows during the salmon flow objective period (April through August). This project provides for Lake Roosevelt to be drafted an additional 1.0 foot in non-drought years and up to 1.8 feet in drought years by the end of August. One-third of this water will go to instream flows.

The Corps manages some CRS reservoir levels to allow for irrigation on private agricultural lands. The Corps' Northwestern Division Reservoir Control Center coordinates and modifies operations to benefit irrigation at both the John Day and McNary projects. The lower Snake River project also provides irrigation water by maintaining stabilized reservoir levels that enable the installation and operation of pumping stations.

1.3.1.5 Operations for Navigation

The Action Agencies propose to continue operating the eight mainstem projects on the lower Snake and Columbia rivers for navigation (see the BA, Section 2.3.4, for details [BPA et al. 2020]). This includes managing reservoir elevations, filling and draining navigation locks, and maintaining navigation locks. Adjustments in spill or reservoir operating ranges may be required at any of the lower Snake or lower Columbia River projects to address navigation safety concerns and to maintain the authorized depth in the Federal navigation channel. This may include changes in spill patterns, reductions in spill, including short-term spill cessation, or adjustments (increases) to MOP operations. These adjustments may sometimes be necessary during the spring or summer fish passage season and possibly during periods of low or high flows.

1.3.1.6 Operations for Recreation

The Action Agencies propose to continue the operation of the 14 CRS projects to support recreational activities (see the BA, Section 2.3.6, for details [BPA et al. 2020]). This includes managing reservoir elevation and river flows. Both recurring and one-time requests for special operations to support recreation are considered, as long as they are within normal operating limits and other project requirements, including FRM and fish conservation operations.

1.3.1.7 System Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects (see the BA, Section 2.4, for additional details [BPA et al. 2020]). This includes scheduled or routine maintenance of fish facilities, spillway components, navigation locks, generating units, and supporting systems to ensure project reliability and to comply with North American Electric Reliability Corporation/Western Electricity Coordinating Council regulatory requirements.

Routine maintenance includes measures to reduce or contain the releases of oils and greases from Federal dams into the Snake or Columbia Rivers. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, “environmentally acceptable lubricant” greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and is implementing oil accountability plans with enhanced inspection protocols for the four lower Snake River and four lower Columbia River projects to comply with the Clean Water Act.

At Bonneville Dam, periodic dredging in the forebay is required to ensure reliable operation of fishways. The area near the Bradford Island Fish Ladder exit is surveyed annually, and material is dredged every year or two. Similar work is done near the turbine units that supply attraction water to the Washington Shore Fish Ladder. A barge-mounted suction or clamshell dredge is used to remove material for eventual upland disposal, and standard turbidity control measures are employed. The operation generally occurs every other year, takes 1 week to complete, and would continue to be conducted during the in-water work period (December to March), in accordance with the Fish Passage Plan.

Spill operations at Bonneville Dam routinely pull large rock material onto the spillway apron. This material must be routinely removed to prevent structural damage and disruption to spill operations and minimize impacts on fish. Rock removal is generally needed every year that spill exceeds 150 kcfs, approximately 7 years out of 10. Hydrosurveys will continue to be conducted annually, usually in September, and will typically take one day to complete. Rock material removal would occur during the in-water work period (December to March), in accordance with the Fish Passage Plan and in coordination with FPOM. Rock material is typically removed using a clamshell dredge mounted on a barge, then placed at upland disposal sites.

At Dworshak Dam, there are three generating units, which discharge into the North Fork of the Clearwater River. From September 15 through the end of February, the units are taken down one at a time to perform annual inspection and maintenance. One of the generating units is brought down for 6 weeks for cavitation repair. This outage is scheduled first, because the turbines must be dewatered to provide access. Each of the remaining units is typically out of service for 2 to 4 weeks during this annual inspection and maintenance period. Similar to turbine maintenance at Chief Joseph Dam, fish protection protocols have been developed for turbine dewaterings at Dworshak Dam in response to a past event that resulted in the loss of adult B-run steelhead. These protocols began being implemented in 2017, are included in the Fish Passage Plan, and are coordinated through the FPOM coordination team. Fish protection protocols for unit operation testing will continue to be developed by the Corps in coordination with NMFS and USFWS. To further minimize and avoid injury and mortality to Snake River Basin (SRB) steelhead, the Corps will continue to implement and improve protocols regarding Dworshak Dam turbine unit operations and maintenance and associated FPOM coordination, consistent with the 2020 Fish Passage Plan.

System maintenance also includes maintenance that is not planned, referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events are unforeseeable. These events are communicated through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize negative effects on fish.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance is not performed at a regular predetermined frequency, and includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization and major rehabilitations of CRS project features, described below.

During the expected timeframe of this consultation, improved fish passage (IFP) turbines will be installed at three out of six turbine units at Ice Harbor Dam. At McNary Dam, the status of turbine replacement is near the completion of the design phase and is expected to begin replacement within the next 15 years. At John Day Dam, the design phase has begun but it is uncertain whether turbine replacement will be completed within the 15 year period of the proposed action. The Action Agencies, in coordination with NMFS, will consider cessation of turbine intake bypass screen installation at these projects if direct fish passage survival studies demonstrate a neutral or beneficial effect.

The Corps will repair the existing jetty and retaining wall located near the north shore adult ladder entrance at Little Goose Dam, where significant erosion has occurred. During unusually high flows in 2011, the jetty rock was severely degraded, which led to the ladder entrance flow becoming somewhat degraded by the tailrace eddy flow when spill exceeds 30 percent. Replacing the jetty with large rock and/or large coffer cells will restore passage conditions to pre-2011 levels at the north shore ladder entrance when spill exceeds 30 percent at Little Goose Dam.

1.3.2 Non-Operational Conservation Measures to Benefit ESA-listed Salmon and Steelhead

In addition to the operational measures described above, the Action Agencies propose to continue non-operational conservation measures to address uncertainty regarding the effects of further increases in spring spill, and to help offset any residual adverse effects of system management. These non-operational measures include support for conservation hatchery programs, predation management, and habitat improvement actions in the Columbia River estuary and various tributaries. The Action Agencies' approach to mitigating the effects of CRS management on ESA-listed salmon and steelhead is consistent with conservation strategies established in regional salmon and steelhead recovery planning processes.

1.3.2.1 Structural Modifications at Mainstem Dams

The Action Agencies propose to implement several structural modifications at the lower Snake and Columbia River dams. These modifications are described in more detail in the BA (see the BA, Section 2.6.1.1, for details [(BPA et al. 2020]).

At Lower Granite Dam, the Corps will monitor the recently constructed follow-on modifications to the juvenile bypass separator which were implemented to reduce delay, injury, and stress to salmon and steelhead, bull trout, and non-target species. Where beneficial and feasible, the Corps in coordination with NMFS will develop and implement operational or structural solutions if monitoring indicates the new modifications are ineffective.

Consistent with the recommendations presented in NMFS' 2015 Adult Sockeye Salmon Passage Report (NMFS 2016a), the Corps will continue monitoring and reporting all mainstem fish ladder temperatures and identify ladders that have substantial temperature differentials (>1.0 degrees Celsius [°C]). Where beneficial and feasible, the Corps will develop and implement operational or structural solutions to address maximum temperatures and temperature differentials in adult fish ladders at mainstem lower Snake and Columbia River dams identified as having these problems.

The Corps will implement enhanced debris management at lower Snake River and lower Columbia River projects. Seasonally, pulses of woody debris can accumulate on turbine unit trash racks and enter bypass systems and can injure ESA-listed salmonids and cause considerable maintenance challenges for dam operators. In recent years, Lower Granite Dam's debris boom used in conjunction with the removable spillway weir have effectively passed large amounts of debris, increasing debris loads at downstream dams. In response, the Corps has begun to identify potential new operational or structural solutions for managing debris. The Corps will continue to investigate potential operational or structural solutions for effective forebay debris management at lower Snake River and lower Columbia River dams. Where necessary and feasible, the Corps will design and implement solutions designed to minimize and reduce ESA-listed salmonid injury and mortality associated with debris accumulation.

1.3.2.2 Conservation and Safety Net Hatchery Actions

To support ESA-listed salmon and steelhead species affected by CRS management, the Action Agencies will continue to fund the operation and maintenance of safety net and conservation hatchery programs that preserve and rebuild the genetic resources of ESA-listed salmon and steelhead in the Columbia and Snake River basins. The purpose of conservation programs is to rebuild and enhance the naturally reproducing ESA-listed fish in their native habitats using locally adapted broodstock, while maintaining genetic and ecological integrity and supporting harvest where and when consistent with conservation objectives. Safety net programs are focused on preventing extinction and preserving the unique genetics of a population using captive broodstock to increase the abundance of the species at risk.

1.3.2.2.1 Conservation and Safety Net Hatcheries

The Action Agencies note the continued existence of their respective independent congressionally authorized hatchery mitigation responsibilities, including, but not limited to, Grand Coulee Dam mitigation, John Day Dam mitigation, and programs funded and administered by other entities, such as the Lower Snake River Compensation Plan, which is administered by USFWS. Similar to the conservation and safety-net programs, and where appropriate, the Action Agencies will conduct or have conducted separate consultations addressing effects to ESA-listed species from CRS operations and maintenance, as well as associated monitoring and evaluation (including tagging) for these programs (Table 1.3-4)

Table 1.3-4. Action agency-funded conservation and safety net hatchery programs included in this consultation.

Species	Hatchery Program	Population	Program Type	Operator	Action Agency Funding Source	NMFS Biological Opinion Status	USFWS Biological Opinion Status	Production level approved in NMFS BiOp
Upper Columbia River Spring Chinook	Winthrop NFH Spring Chinook Program[1]	Methow Spring Chinook	Integrated conservation	USFWS	Reclamation	Final biological opinion 10/13/2016	May 13, 2016	Up to 400,000 smolts
Upper Columbia River Steelhead	Winthrop Steelhead Program	Winthrop Steelhead	Integrated conservation	USFWS	Reclamation	Final biological opinion 10/10/2017	May 13, 2016	Up to 200,00 smolts
Upper Columbia River Spring Chinook	Chief Joseph Hatchery Program/ Winthrop NFH	Okanogan Spring Chinook	Isolated conservation (10j)	Colville Tribe/ USFWS	BPA/ Reclamation	Final Chief Joseph Hatchery biological opinion 10/27/2014 Final biological opinion WNFH 10/13/16	May 13, 2016	Up to 200,000 smolts
Snake River Spring Chinook	Johnson Creek Spring Chinook Program	Johnson Creek	Integrated recovery	Nez Perce Tribe	BPA	Final biological opinion 11/27/2017	Final biological opinion 12/08/2017	Up to 150,000 smolts

Species	Hatchery Program	Population	Program Type	Operator	Action Agency Funding Source	NMFS Biological Opinion Status	USFWS Biological Opinion Status	Production level approved in NMFS BiOp
Snake River fall Chinook	Nez Perce Tribal Hatchery fall Chinook Salmon Program	Clearwater basin	Integrated recovery	Nez Perce Tribe	BPA	Final biological opinion 08/13/2018	Final biological opinion 05/16/2017 Amended 07/20/2018	Up to 1,400,000 sub-yearlings
Snake River Sockeye	Snake River Sockeye Salmon Captive Broodstock Program	Redfish Lake	Integrated recovery	Idaho Department of Fish and Game	Bonneville	Final biological opinion 9/28/2013	Final biological opinion 12/18/2017	Up to 1,000,000 smolts

[1] The Upper Columbia River spring Chinook salmon and steelhead hatchery programs included in this table serve as both conservation programs and the Grand Coulee mitigation programs.

1.3.2.2.2 Conservation Actions for Lamprey

The Action Agencies propose to implement several structural measures designed to improve passage and survival of Pacific lamprey (*Entosphenus tridentatus*) as funding becomes available. Any structural or operational changes intended to improve passage conditions for Pacific lamprey will be coordinated with the Services to ensure neutral to beneficial effects on ESA-listed species. The Action Agencies propose the following structural measures to improve lamprey survival:

- Modify turbine intake bypass screens that cause juvenile lamprey impingement. The Corps will replace existing extended-length bar screens with screens designed to reduce juvenile lamprey entanglement at Little Goose and Lower Granite Dams. The upgrades would occur when existing screens need replacement.
- Expand network of lamprey passage structures in fish ladders at Bonneville, The Dalles and John Day Dams, and modify existing structures.
- Modify turbine cooling water strainer systems to safely exclude juvenile lamprey.
- Modify existing fish ladders, incorporating lamprey passage features and criteria into ladder modifications at lower Snake and Columbia River dams. Modifications may include ramps to submerged weir orifices, diffuser plating to provide attachment surfaces, diffuser grating with smaller gaps, refuge boxes, wetted walls, rounded weir caps, and closure of floating orifice gates.
- Modify the upper fish ladder sections at Bonneville Dam's Washington Shore and Bradford Island ladders. The Corps would replace the existing serpentine weir flow control sections with Ice Harbor-style vertical slots and submerged orifices. Based on similar modifications at John Day Dam, this modification is expected to reduce ladder passage times and improve passage success for lamprey, and may also result in reduced passage times for salmon and steelhead. This modification would occur within the typical in water work maintenance period and will not likely result in additional fish ladder outages.

1.3.2.3 Predator Management and Monitoring Actions

The Action Agencies propose to continue actions to reduce the number of ESA-listed salmon and steelhead that are impacted by predators (see BA Section 2.6.1.3 for details):

- Pinniped Management at Bonneville and The Dalles Dams:
    - Install and potentially improve sea-lion exclusion devices in ladder entrances at Bonneville Dam;
    - Provide dam access and, as practicable, other support (e.g., crane support) for land- and water-based harassment and trapping efforts by state and tribal agencies;

- The Corps will fund dam-based hazing (focusing on deterrence from fishway entrances) and haul out dissuasion of pinnipeds from March 31 through May 31 and from August 15 through October 31 at Bonneville Dam. Hazing season start and end dates may be adjusted, in coordination with NMFS, based on factors such as the number of animals present and hazing effectiveness.
- Develop and implement, in coordination with NMFS, a revised Bonneville Dam pinniped predation monitoring plan that reflects current and near-future management needs. The Corps will continue to provide monthly and annual reports to NMFS and FPOM.
- Haze pinnipeds observed in the vicinity of fish ladder entrances at The Dalles Dam as needed.

- Pikeminnow Predation Management:
  - Implement the Northern Pikeminnow Management Program (NPMP), including the Sport Reward Fishery (May through September) and Dam Angling programs (May through October).
  - Work with partners to understand and develop new management opportunities, strategies, and sampling methods that replace electrofishing (used for both pikeminnow tagging/reward fishery removal and "biological evaluation" data collection).
  - Adaptively manage the Dam Angling Program component to address new site-specific predation using test fisheries along Snake River hydroelectric projects.
  - Coordinate with the Services regarding locations of future actions within the Dam Angling Program, especially if new site-specific predation locations become a priority.

- Avian Predation Management:
  - Implement the Inland Avian Predation Management Plan (IAPMP). The Corps will monitor presence/absence of Caspian terns (once during the breeding season) on Crescent Island indefinitely. Reclamation will continue to monitor, and passively and actively dissuade, Caspian terns, and (optionally) lethally take up to 200 tern eggs (all sites combined) on Goose Island and other areas in the North Potholes Reservoir until permanent and sustainable nesting deterrents achieve the metric thresholds (fewer than 40 breeding pairs/site, and less than 200 breeding pairs all sites combined) outlined in the IAPMP. At the conclusion of the Avian Predation Synthesis Report, and informed by preliminary information from the 2020 studies funded by BPA and the Priest Rapids Coordinating Committee (PRCC), the Action Agencies will coordinate with the Services through the appropriate Regional Forum workgroup (e.g., FPOM) to determine need for and scope of future Action Agency-sponsored inland avian predation management and monitoring in the Columbia Plateau.

- Implement the Caspian Tern Management Plan. On East Sand Island, the Corps will continue to implement management actions, including preparing 1.0 acre of suitable tern nesting habitat and passive and active dissuasion outside the 1.0 acre tern nesting area. The Action Agencies will monitor peak colony size (nesting pairs) and predation rates (on passive integrated transponder (PIT)-tagged juvenile salmon) until actions achieve the management goal: less than 4,375 breeding pairs (3-year average). To date, this management goal has been met in 2 of the past 3 years—2017 and 2019, respectively. Afterwards, the Caspian tern East Sand Island peak colony size and predation impact/rates on PIT-tagged juvenile salmonids will be monitored, as warranted by study findings and regional coordination. At the estuary dredge material placement islands (Rice, Miller, Pillar and other locations as warranted), the Corps will conduct active and passive dissuasion, potentially lethally take up to 100 tern eggs, and monitor tern presence/absence, per commitments under a separate 2012 biological opinion (NMFS 2012a). Further, if warranted at the alternative (constructed) sites in Oregon and Northern California, the Corps will maintain nesting habitat to attract and retain terns until those islands are legally transferred to Oregon, Washington, or USFWS. Upon receipt of the final Avian Predation Synthesis Report, and informed by preliminary information from the 2020 studies funded by BPA and the PRCC, the Action Agencies will work with NMFS and USFWS through the appropriate Regional Forum workgroup (e.g., FPOM) to determine need for and scope of future Action Agency-sponsored Caspian tern management and monitoring in the Columbia Plateau.
- Implement the East Sand Island Double-Crested Cormorant Management Plan. On East Sand Island, the Corps will continue to implement Phase 2 management actions, including active and passive dissuasion and (optionally) lethally take up to 500 double-crested cormorant eggs, as warranted. The Action Agencies will monitor peak colony size and predation rate (on PIT-tagged juvenile salmon) through 2020 and as needed thereafter. In the Columbia River estuary, the Corps will also monitor dispersal, disposition (e.g., roosting, nesting, etc.) and colony size through 2020 and as needed thereafter. On the estuary dredge material placement Islands (Rice, Miller, Pillar and other locations as warranted), the Corps will conduct passive and active dissuasion, (optionally) lethally take up to 250 double-crested cormorant eggs, and monitor this species' presence/absence, per commitments in NMFS (2012a). Upon receipt of the final Avian Predation Synthesis Report, and informed by preliminary information from the 2020 studies funded by Bonneville and the PRCC, the Action Agencies will work with the Services through the Regional Forum workgroup (FPOM) to determine need for and scope of future Action Agency-sponsored double-crested cormorant management and monitoring on East Sand Island and the larger Columbia River estuary.
- The Action Agencies will complete:
  - Synthesis of avian predation data collected through implementation of the three avian management plans for assessing the effectiveness of these actions on a

basinwide scale. In 2020, BPA is funding an analysis of presence/absence, abundance, and colony-specific information, and predation rates of piscivorous waterbird colonies (including unmanaged sites) within the lower Columbia River, from McNary Dam downstream through the Columbia River estuary.

- Avian predation deterrence at lower Columbia and lower Snake River dams. The Corps will continue avian predation deterrence and monitoring activities at all eight lower Columbia and lower Snake River dams. At each dam, bird numbers will continue to be monitored, birds foraging in dam tailraces will be hazed (to include, in some circumstances, lethal reinforcement), and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed.
- Avian predation deterrence operation of John Day Reservoir (see also Section 1.3.1.2.5 for a full description of the operation). The Action Agencies propose to increase the normal forebay operating range at John Day Dam by 2 feet during April 10 through June 1 to deter Caspian terns from nesting at the Blalock Islands Complex. The purpose of this operation is to reduce predation pressure on spring migrating, ESA-listed juvenile salmon and steelhead.

1.3.2.4 Estuary Habitat Actions

The Action Agencies propose to continue implementing the Columbia Estuary Ecosystem Restoration Program (CEERP) to increase the capacity and quality of estuarine ecosystems, and improve the opportunity for access by juvenile salmonids. This element of the proposed action will help address uncertainty related to any residual effects of the proposed action for the CRS, including uncertainty regarding such effects in the face of climate variability.

The Action Agencies propose to prioritize habitat improvement sites by identifying regions with the greatest potential to benefit yearling and subyearling life-history types of ESA-listed salmon and steelhead. Examples of potential actions include: reconnecting floodplains, recreating wetland channels, enhancing riverine habitat, removing fish passage barriers, reducing non-native species, and restoring native vegetation. The Action Agencies will continue to use the Expert Regional Technical Group (ERTG) to provide technical information and analysis of issues to the Action Agencies regarding the most effective types of actions to pursue in the estuary (i.e., what actions will result in the greatest benefit), assist the Action Agencies in developing project prioritization criteria, and reviewing completed projects.

The Action Agencies propose to reconnect an average of 300 acres per year to the tidal regime for the duration of the proposed action. They note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a “5-year rolling review,” which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan. The CEERP will continue to include action effectiveness monitoring and research (AEMR) using a three-level approach[12] to improve the estuary habitat program as information becomes available that addresses current and future uncertainties. Several efforts are already underway, including:

- Synthesis Memorandum. Every 5 years or so, the Action Agencies will reevaluate the state of the science, their accomplishments to date, and the effects and trends of estuary habitat improvement actions. The latest memorandum was finalized in 2018.
- ERTG's Landscape Perspectives. The Action Agencies, NMFS, and ERTG continue to consider landscape ecology concepts and principles that can refine and direct where to focus future restoration efforts.
- Uncertainties research. With the development of additional landscape criteria, ERTG will revisit and rank the critical uncertainties that require new or continued attention. These recommendations, along with lessons learned and key findings from the Action Agencies' RME program, will guide future research objectives and study designs.

The intent of each of the undertakings listed above is to refine and learn a more effective approach to restoring estuary habitat. The Action Agencies describe these proposed endeavors, and their continued on-the-ground habitat improvement, as a commitment and willingness to analyze the outcomes and results of these actions to improve their understanding and the effectiveness of habitat improvement in the estuary.

1.3.2.5 Tributary Habitat Actions

The Action Agencies propose to implement targeted tributary habitat improvement actions as offsite mitigation to help address uncertainty related to residual adverse effects of CRS management on the listed salmon and steelhead that migrate through the CRS, including uncertainty regarding such effects in the face of climate change (see the BA [BPA et al. 2020, Section 2.6.1.4 and Appendix D, and USACE 2020], for details).

1.3.2.5.1 Implementation Approach

The Action Agencies commit that their tributary habitat improvement actions will be informed by recovery plans and other best available information and science, will build adaptively on the science-based strategies and research and monitoring information developed during implementation of tributary habitat improvement actions under the 2008/2010/2014 biological opinions and the 2019 biological opinion, and will maintain the extensive network of

[12] The three levels of AEMR move from intensive to extensive: "intensive AEMR" examines ecosystem processes and functions, e.g., juvenile salmon species composition, density, diet, and growth, along with structures and controlling factors; Level 2, "core AEMR," assesses core indicators of ecosystem structures and controlling factors such as plant species composition, percent cover, and biomass (Roegner et al. 2008); and Level 3, "standard AEMR," monitors key controlling factors and other indicators, e.g., photo points, water surface elevation, and salinity.

collaboration with local experts and implementing partners developed under those biological opinions.

Implementation will be guided by the Tributary Habitat Steering Committee (THSC), which was established under the 2019 biological opinion. In addition, a Tributary Technical Team will be formed to provide scientific guidance to support implementation of the program and to help ensure that program goals and objectives are achieved.

The Action Agencies will focus implementation of tributary habitat improvement actions on priority populations. Initially, these will be the priority populations identified in the 2008 biological opinion, but the Action Agencies will work with NMFS to refine population priorities. The Action Agencies will prioritize actions based on locally developed implementation strategies that prioritize actions based on assessments of limiting factors and, eventually, of habitat capacity by species and life stage. Such assessments will identify watersheds and action types believed to offer the greatest potential to contribute to species viability. Action prioritization will also consider climate impacts as relevant to action locations and types. Input from the Tributary Technical Team will also inform action prioritization. In general, the Action Agencies intend that actions to improve habitat complexity will be the primary effort under this proposed action, with a corresponding focus on larger and more complex actions.

1.3.2.5.2 Implementation Commitments: Actions, Metrics, and Plans

For the period covered by this consultation, the Action Agencies will complete, or have in process, habitat improvement actions for three MPGs within the Snake River (SR) spring/summer Chinook salmon ESU, for four MPGs within the SR steelhead DPS, and for Upper Columbia River (UCR) spring-run Chinook salmon and UCR steelhead. Specific metrics that the Action Agencies have committed to are included herein in the effects analysis for each of these four species (see Sections 2.2.3.1.8, 2.3.3.1.8, 2.6.3.1.8, and 2.7.3.1.8).

In addition, the Action Agencies may implement habitat improvement actions for Mid-Columbia River (MCR) steelhead and for the populations of Columbia River (CR) chum, LCR coho, LCR Chinook, and LCR steelhead that have been affected by CRS management.

The Action Agencies will develop, with input from NMFS, a series of prospective 5-year implementation plans that outline the specific actions the Action Agencies intend to implement in that timeframe.

1.3.2.5.3 Implementation Reporting

The Action Agencies will provide NMFS with information sufficient to ensure that implementation is consistent with the level of effort committed to in the proposed action, and to evaluate the implementation and effectiveness of the tributary habitat improvement program both quantitatively (e.g., through life-cycle modeling) and qualitatively. During the first year of the proposed action, the THSC, in collaboration with the Tributary Technical Team, will coordinate the final requirements for implementation reporting, and will assure that reporting objectives are met.

The Action Agencies will report annually on implementation, with a more comprehensive report on, and analysis of, implementation at 5-year intervals.

1.3.2.5.4 Climate Change

Many of the habitat improvement actions planned, designed, funded, and implemented by the Action Agencies will help support resilient habitats and flexibility to adjust to climate change. For example, actions to enhance riparian areas, stream complexity, and stream flow will help to ameliorate streamflow and temperature changes and increase habitat diversity and population resilience. As stated above, climate change information will be used in the development of action prioritization.

1.3.2.5.5 Research, Monitoring and Evaluation

The Action Agencies will continue to: monitor habitat status and trends (including stream temperature and flow); conduct compliance and implementation monitoring (to ensure that habitat improvement actions are implemented as planned); monitor effectiveness of their habitat mitigation efforts at a range of scales; fund fish and habitat monitoring; and, support research projects with regional partners as funding and priorities allow.

The Action Agencies will implement a tributary habitat RME program to assist in regional efforts to assess tributary habitat conditions, limiting factors, and habitat-improvement effectiveness and to address critical uncertainties associated with offsite habitat mitigation actions. The habitat RME program is structured to include compliance, implementation, effectiveness, and status and trends monitoring and research. The Action Agencies' RME efforts are intended to work in concert with similar efforts funded by other Federal, state, tribal, utility, and private parties that, when combined, will contribute to basinwide RME data and analyses.

The Action Agencies have also committed to engaging in a collaborative process with NMFS, the USFWS, the Northwest Power and Conservation Council, Tribes, and other regional partners to develop and implement a Columbia River Basin tributary habitat research, monitoring, and evaluation strategy that will align with and directly support project documentation and project effectiveness to meet the needs of the THSC and Tributary Technical Team. Further, the Action Agencies will coordinate with NMFS, the USFWS, the THSC, and other regional partners to identify core habitat data objectives, evaluate the success of the Action agencies' program, and support adaptive management. During the development of this habitat RME strategy, the Action Agencies will continue to fund tributary habitat RME to address interim needs and habitat management applications during the term of this consultation.

1.3.3 Conservation Measures for Kootenai River White Sturgeon

BPA will provide funding and/or technical assistance to support implementation of a variety of activities to benefit sturgeon, including conservation aquaculture, habitat, and other actions, as described further below. Planning and implementation for the habitat and nutrient enhancement actions occur in 5-year phases using an adaptive management approach to inform decisions regarding performance of these actions in addressing physical limiting factors for sturgeon. Funding of conservation measures for Kootenai River white sturgeon after 2025 will be subject to BPA's prioritization of available funds; investments in fish and wildlife by BPA for protection, mitigation, and enhancement will be prioritized based on their biological benefits and cost-effectiveness and their connection to mitigating the impacts of the CRS. A brief description of the various activities undertaken for the conservation of Kootenai River white sturgeon follows.

1.3.3.1 Conservation Aquaculture

As part of the proposed action, BPA will provide funding in accordance with the terms outlined in the Memorandum of Agreement between BPA and the Kootenai Tribe of Idaho (KTOI) for the KTOI's Kootenai River Native Fish Conservation Aquaculture Program for sturgeon. The conservation aquaculture program incorporates both short- and long-term objectives, with production strategically determined annually based on RME and in coordination with regional partners. Restoration opportunities will be identified by a variety of means, including analysis of limiting factors; expert knowledge of specific conditions; field assessments; interpretation of aerial imagery to identify land use, open water features, current tributary alignments, and existing stands of vegetation; and analysis of spatial data layers, including land cover classification mapping, modern and historical wetland distribution within the floodplain, soil characteristics, floodplain elevations relative to current bank-full flows, and parcel ownership.

1.3.3.2 Habitat Improvement Actions

As part of the proposed action, Bonneville will continue to implement habitat actions in the Kootenai River to benefit Kootenai River white sturgeon, using a tiered, reach-specific restoration strategy to help guide identification and development of site-specific habitat restoration actions. The Action Agencies will work with implementation partners, including the KTOI, Idaho Department of Fish and Game (IDFG), and existing advisory teams (e.g., Co-manager Advisory Team and Peer Review Advisory Team) to identify and prioritize restoration opportunities in the Braided Reach and Meander Reach during the first 5 years of the period covered by this consultation.

Each restoration opportunity incorporates a number of different restoration treatments and is designed to address reach-specific limiting factors and restoration strategies, which are grouped together into restoration nodes. An initial prioritization of these restoration nodes is complete; however, the details of the specific actions to be implemented in 2021 through 2025 will be determined based on a two-tiered approach to project categorization, with priority given to Tier 1 actions over Tier 2 actions, as described further below. The Action Agencies expect to initiate, on average, one comprehensive Tier 1 action per year in the near term (2021 to 2025) of this action to benefit Kootenai River white sturgeon.

Tier 1 and Tier 2 actions are described below:

- Tier 1 Action Categories:
  - Floodplain restoration and enhancement. Restoration of floodplain habitat in the Meander Reach will improve overall ecosystem health for a range of species present in the Kootenai River, including white sturgeon. These actions are the highest priority for funding because they will contribute the most to improving ecosystem function. Large cottonwood plantings and wetland riparian revegetation discussed in the Columbia River System Operations EIS are considered part of the Kootenai River white sturgeon Tier 1 actions for floodplain restoration and enhancement.
  - Maintenance of existing habitat projects. To ensure that previously completed habitat actions continue to benefit Kootenai River white sturgeon, it may be necessary to conduct maintenance actions at these existing habitat projects (i.e., replacing woody material, replanting, and pool deepening). When these maintenance activities are necessary to maintain or return functionality, then these actions will count toward the one project per year target during the first 5 years of this consultation.
  - Restoration of Kokanee Spawning Habitat. Habitat enhancement actions within the tributaries of the Kootenai River may increase kokanee spawning potential, and further promote juvenile to adult survival of kokanee salmon. Kokanee salmon serve as an important prey species for sturgeon and bull trout. Actions of enhancement may include improving tributary confluence areas by increasing their depth, adding complexity and cover, reducing sediment deposition, and reestablishing the floodplain and the native vegetation upon it.

- Tier 2 Action Category:
  - Supplemental spawning gravel. Placement of suitable substrate materials (for instance, clean rock) near known sturgeon spawning areas may occur as a Tier 2 action. If enacted, gravel of approximately 3 to 8 inches may be placed on the river bottom in layers representing a gravel mat of up to 1 foot of thickness. This gravel may further promote egg attachment, reduce potential for egg suffocation, and provide hiding cover for hatched larval sturgeon.

The coming years will provide important additional data about whether ecosystem-based improvements are effective at spurring changes in sturgeon reproductive behavior in the wild. Therefore, following the initial 5-year commitment, the Action Agencies will work with USFWS and implementation partners to evaluate the current conservation status and needs of Kootenai River white sturgeon to determine scope and scale of actions appropriate to consider implementing for the remainder of the period covered by this action. The Action Agencies therefore commit to work collectively with the Services, implementation partners, and technical advisory teams to evaluate progress in approximately 2025 and assess whether adaptive management changes are warranted in this ecosystem-based approach.

The Action Agencies expect that these prospective actions, combined with the comprehensive improvements in spawning and rearing habitat already implemented, as well as continued nutrient additions and Libby Dam operations designed to cue spawning behavior, will be sufficient to establish conditions favorable for enabling sturgeon reproduction and carrying capacity when these long-lived species reach sexual maturity.

Site-specific effects on bull trout, Kootenai River white sturgeon, and their designated critical habitat from implementation of future restoration actions under the Kootenai River Habitat Restoration Program will be addressed through the USFWS' 2013 programmatic biological opinion for the program.

1.3.3.2.1 Adaptive Management

Throughout the duration of the proposed action, implementation of habitat actions to conserve Kootenai River white sturgeon will be periodically reviewed and adaptively managed in 5-year cycles with an existing commitment to initiate at least one Tier 1 habitat project per year from 2021 to 2025. During this time, the Action Agencies, in coordination with the USFWS and other relevant regional stakeholders, will use a process of regional coordination to develop a 5-year implementation plan(s). Because of climate change vulnerabilities, Kootenai River white sturgeon population status, and density dependence concerns, conservation priorities may change in scale, scope, sequencing, or focus as more individuals in the river become sexually mature and previously completed actions mature, resulting in more ecological benefits being fully realized.

The 5-year plan(s) will focus on the following activities:

- Identify and prioritize actions for implementation, seek potential for refinement in methods used for identification and prioritization of actions based on Kootenai River white sturgeon conservation needs.
- Use the best available science at a watershed and reach scale to identify and prioritize actions to address key limiting factors for Kootenai River white sturgeon.
- Implement high-priority, strategic habitat restoration projects that produce measurable results.
- Maintain a living and collaborative prioritization framework that demonstrates objectivity, transparency, and accountability, and manage the prioritization framework and associated project implementation adaptively to ensure maximum biological benefit.
- Generate a set of scored and ranked criteria, developed and approved by local and regional fish research and habitat biologists, ecologists, geomorphologists, and engineers, that facilitates the ranking of conceptual restoration opportunities based on their biological benefits.

An adaptive conservation approach acknowledges the changing nature of the factors that may aid our understanding of which actions will provide the greatest benefits. The management approach has to remain nimble enough to respond to new and evolving information. For additional information, see the discussion on *Adaptive Management of Program Performance Metrics* in BPA et al. (2020), Appendix D—Supplemental Narrative for Tributary Habitat Actions.

1.3.3.2.2 Nutrient Enhancement

The construction of Libby Dam and the closure of the fertilizer mine upstream in British Columbia altered the availability of nutrients in the Kootenai River below Libby Dam, and downstream into Kootenay Lake in British Columbia. Lake Koocanusa, the reservoir created by Libby Dam in Montana, acts as a nutrient sink, retaining approximately 63 percent of total phosphorus (P) and 25 percent of total nitrogen (N), although levels of dissolved inorganic N have been increasing recently above and below Libby Dam. The low levels of P and N have resulted in oligotrophic (i.e., having a deficiency of plant nutrients) and ultra-oligotrophic conditions in most reaches of the Kootenai River. These effects are also evident in Kootenay Lake, because the Kootenai River provides approximately 60 percent of the inflow to Kootenay Lake. Altered N and P ratios (in combination with other factors) in Kootenay Lake have been shown to limit food web and fisheries development. The productivity of both Kootenay Lake and the Kootenai River are important to the growth and health of sturgeon.

To mitigate the reduced nutrient availability and associated biological productivity in the Kootenai River and Kootenay Lake, the International Kootenai Ecosystem Recovery Team recommended a 5-year experimental nutrient restoration effort in the Kootenai River in 2003, and extended the program to Kootenay Lake in 2004. Both programs continue today and are briefly summarized below.

1.3.3.2.3 Kootenai River Nutrient Enhancement

The nutrient supplementation consists of finely measured additions of liquid P to the Kootenai River near the Idaho-Montana border. If the ambient N:P ratio drops below a predetermined level, then N may be added, as happened briefly in 2009. Generally, application of nutrients is metered out over time through an automated apparatus. Nutrient addition since 2013 occurs from March 15 to October 31 annually. The Action Agencies will continue to support the existing nutrient addition program during the period of this consultation.

The RME component of the project collects water quality and algal, macroinvertebrate, and fish data. Results of this monitoring found statistically significant responses of fish productivity over baseline measures during the first 5 years of the program. These results, coupled with other reported findings from the lower trophic levels, demonstrate a significant positive benefit and provide support for continued nutrient addition as an ongoing management activity in the Kootenai River. Based on these results, BPA proposes to continue funding this action through fiscal year 2025 and will continue to use RME results to inform future management decisions.

1.3.3.2.4 Kootenay Lake Nutrient Addition

Experimental annual nutrient additions to the South Arm of Kootenay Lake began in 2004. Under this program, fertilizer is added each year from June through August. Kootenay Lake nutrification occurs via releases from boat-mounted tanks, with application carried out over a predetermined course or courses. These actions have been implemented and monitored by the British Columbia Ministry of Forests, Lands and Natural Resource Operations, with BPA funding.

Since nutrient addition began in the South Arm of Kootenay Lake in 2004, numbers of native kokanee salmon, a significant food source for adult and juvenile Kootenai sturgeon, have tripled and rainbow trout biomass has doubled. Additionally, significant numbers of kokanee salmon have begun to return to South Arm Kootenay Lake tributaries in British Columbia and Kootenai River tributaries in Idaho. This indicates that, in combination with the physical habitat restoration work on the tributaries, nutrient mitigation actions in the Kootenay Lake are working together to benefit the larger ecosystem. Based on this successful response to Kootenay Lake nutrient additions, BPA proposes to continue funding this action through fiscal year 2025 and will continue to use RME results to inform management decisions regarding future actions.

Monitoring and Evaluation for Kootenai River white sturgeon

Monitoring and evaluation activities funded by Bonneville are intended to achieve the following goals: 1) determine if actions are being implemented as proposed, 2) determine whether actions are effective in addressing the limiting factors they were intended to address (physical and biological), and 3) identify critical uncertainties. Overall, the M&E activities are intended to improve Kootenai River white sturgeon conservation by carrying out the following:

- Continued monitoring of sturgeon behavior into the Braided Reach and beyond to evaluate sturgeon response to completed habitat actions and the flow regime implemented to encourage spawning.
- Continued biological monitoring to better understand natural reproduction and juvenile survival.
- Continued biological and chemical monitoring associated with nutrient enhancement activities.
- Monitoring of existing (constructed) habitat structures to ensure they maintain their designed purpose.

More specifically, the M&E component of the project involves conducting assessments of spawning activity (e.g., substrate mat sampling), collecting information about the population and health of juveniles and adults (e.g., mark-recapture and telemetry tracking of individuals), assessing completed habitat actions, and data management and reporting. M&E involves the continued collection of water quality data, including samples of algae, zooplankton, and macroinvertebrates. Additionally, fish are collected and monitored to determine their distribution, abundance, and other factors that help managers make additional decisions.

These M&E studies build on an existing body of knowledge. Additional priority information needed in this consultation and gathered through M&E will be used to inform and modify existing actions, as well as design future actions as part of BPA's overall adaptive management approach. These M&E studies are subject to modification based on the new scientific information, project results, or other factors that BPA determines would improve or better inform decision-making.

Environmental compliance for M&E is completed by the specific entities conducting the M&E studies, but are typically covered by various ESA Section 10 permits and Section 6 agreements. Because those actions are addressed through separate compliance processes, BPA is not requesting that the effects of those actions be addressed in this consultation, but is simply identifying that they occur to provide broader context for the suite of BPA-funded conservation actions for Kootenai River white sturgeon.

1.3.4 Conservation Measures for Bull Trout

The Action Agencies propose the actions outlined in this section to provide direct and indirect benefits to bull trout.

1.3.4.1 Albeni Falls Actions to Benefit Bull Trout

The Corps, in coordination with BPA, USFWS, and the Kalispel Tribe, completed and approved a planning document regarding the construction, operation, and maintenance of an upstream bull trout passage facility at the Albeni Falls project. The goal is to allow upstream migration past Albeni Falls Dam for bull trout that have been entrained by the dam or for populations that would be reintroduced to the lower Pend Oreille River. The planning document addresses project authority, cost-effectiveness, and technical feasibility, among other issues. On January 11, 2018, the USFWS issued a biological opinion to the Corps on the construction, operation, and maintenance of an upstream fish passage facility at Albeni Falls Dam. The Corps is seeking Congressional funding to pursue further design and eventual construction of the proposed upstream “trap and haul” fish passage facility, and plans to continue coordination with Federal, state, and tribal agencies throughout this process.

Funding for completion of the design of the facility has been appropriated and work will likely begin on this effort in 2020.

1.3.4.2 Kootenai River Perched Tributary Actions

Delta formations at tributaries of Kootenai River downstream of Libby Dam may be causing upstream fish passage barriers to bull trout seeking spawning grounds during late spring and summer months. In 2021, the Action Agencies will contribute funding for an initial assessment of blocked passage to bull trout key spawning tributaries identified by USFWS. The assessment may cover a range of water year types but must include a dry water year to adequately understand the problem. Upon completion of the initial assessment, Action Agencies, in collaboration with local stakeholders and USFWS will develop an action plan and prioritization process for tributaries identified as having blocked passage. Action Agencies will work with USFWS and stakeholders to identify and initiate a process to address 2 restoration and/or improvement projects benefiting upstream passage opportunities over the period of 2021 to

2026. Any additional improvement opportunities to benefit bull trout passage in Kootenai River tributaries will be evaluated based on biological priorities and available funding**.**

1.3.4.3 Lower Columbia and Lower Snake River Actions to Benefit Bull Trout

Many of the proposed structural and operational passage improvements for salmon and steelhead are expected to benefit bull trout. The BA provides additional detail and specificity regarding proposed non-routine maintenance measures (including new IFP turbines at Ice Harbor, McNary and John Day Dams) and other proposed structural measures.

1.3.4.3.1 Bull Trout Monitoring at Lower Columbia and Lower Snake River Dams and Adaptive Management Actions

The Action Agencies will continue to monitor for bull trout at the lower Columbia and lower Snake River dams. The primary means of monitoring bull trout will be through the Corps' adult fish counts program, PIT detection arrays in fish ladders and JBSs, and through the Smolt Monitoring Program (SMP). While fish passage monitoring is discussed below, specific bull trout monitoring objectives include the following:

- Continue to visually count bull trout passing lower Columbia and lower Snake River dam fish ladders. Visual counts will be posted on the adult ladder count website and documented in the Corp's Annual Fish Passage reports. To minimize the risk of missing observations of bull trout in fish ladders, reported daily and annual counts will include both total net passage past count windows (i.e., typical window counts) and the number of sightings (total number of observations, whether individuals were moving upstream or downstream).
- Continue monitoring for migratory bull trout incidentally collected/handled in SMP samples. Specific objectives:
    - Record size and condition (e.g., descaling, injury, GBT) of all bull trout when encountered in SMP samples, consistent with protocols for salmon and steelhead.
    - Scan all bull trout encountered in SMP samples for PIT tags. If untagged, PIT-tag and collect and store genetic samples (fin clips) of tagged bull trout to support annual abundance estimates and spatial distribution monitoring. The Action Agencies will make the genetic samples available to the USFWS upon request.
    - Record and report bull trout observations, condition information, and any other incidental sightings of bull trout in juvenile bypass facilities (e.g., at adult separator bars) to the Fish Passage Center web page http://www.fpc.org/bulltrout/bulltrout_home.html.
- In coordination with the USFWS, use existing PIT detection sites at mainstem dam fish ladders to track the movements and passage behavior of PIT-tagged bull trout.

- Document incidental recovery of bull trout PITs at mainstem nesting colonies within the scope of current East Sand Island management plans or BPA-funded avian predation studies of salmon and steelhead.
- Record and report bull trout observations during condition sampling for transport of juvenile fish.

While there is limited understanding of bull trout passage behavior at mainstem dams, the relative rarity of bull trout in the lower Columbia and lower Snake Rivers makes direct passage evaluations (e.g., active telemetry, acoustic imaging) infeasible. The Action Agencies will continue to rely on passage studies elsewhere (mid-Columbia Public Utility District [PUD] dam passage studies), incidental PIT detections at traps, weirs and electrofishing, visual counts, and evaluations of passage behavior of other salmonids when considering the potential effects of various structural or operational changes on bull trout.

Monitoring objectives will be refined as priorities evolve and the knowledge increases. The Action Agencies will continue to emphasize monitoring that fulfills mitigation requirements and directly informs management needs.

1.3.4.3.2 Downstream Passage (off season) for Bull Trout on Mainstem

The Corps will continue to refine and implement a multi-year research study (described in more detail in the Biological Assessment, Section 2.7.2.3) to determine the frequency, timing, and duration of off-season surface spill needed to effectively pass adult steelhead downstream of McNary Dam. The Action Agencies will assume that modifications to operations or structures designed to safely and effectively pass adult steelhead via surface spill will also benefit bull trout that are attempting to migrate downstream past McNary Dam.

1.3.3.4.3 Tributary Habitat Improvements for Bull Trout

As described in in the BA, the Action Agencies propose to continue to implement prioritized tributary habitat actions that provide biological benefit for the interior Columbia River basin ESA-listed anadromous salmonid species in this consultation. Implemented throughout the interior Columbia River basin, these projects improve habitat through a variety of actions. Examples may include the following:

- Fish passage and barrier removal.
- Fish screening.
- Instream flow acquisition.
- Habitat protection through easement and acquisition.
- River, floodplain and wetland habitat improvements.
- Riparian planting and fencing.
- Watershed enhancement including road removal and addressing invasive plants.

These actions have incidental benefits to bull trout in the targeted area where bull trout and salmonid species coexist. When developing tributary habitat projects for salmon in areas where bull trout are present, the Action Agencies will proactively engage with USFWS to leverage benefits for bull trout where feasible.

1.3.3.4.4 Spawning Habitat Augmentation at Lake Roosevelt

In Lake Roosevelt, changes in elevation would result in higher rates of kokanee and burbot egg dewatering in winter, and lower reservoir levels in spring would decrease access to tributary spawning habitat for redband rainbow trout. Increased flexibility of refilling Lake Roosevelt that may occur through the month of October, depending on the annual water conditions, may impact the spawning success of kokanee, burbot and redband rainbow trout. In 2019, Bonneville funded year one of a three year study to determine potential impacts of modifications in Lake Roosevelt refill to resident fish spawning habitat access. Other evaluations will be conducted to determine potential impact areas. If study evaluations and other available data indicate resident fish spawning habitat areas are impacted by changes in reservoir elevations, the co-lead agencies will work with regional partners to determine where to augment spawning habitat at locations along the reservoir and in the tributaries (up to 100 acres).

1.3.5 Status and trends of habitat and fish

The Action Agencies will support the annual collection of habitat status and trends information, including stream temperature and flow across the Columbia River basin. The Action Agencies will continue to implement regional habitat data collection to support existing long-term habitat monitoring efforts in a subset of watersheds within the action area. The Action Agencies will also continue to support fish status and trend monitoring for one population per MPG for multiple life stages using a variety of sampling methods within portions of the action area.

Additional monitoring for habitat or fish status and trends will be considered in the forthcoming Columbia River basin tributary habitat RME strategy, to be developed through regional collaboration and scheduled for finalized within 2 years of the completion of this consultation (i.e., the issuance of NMFS' biological opinion).

1.3.6 Compliance, Implementation, and Effectiveness Monitoring

The Action Agencies will fund ongoing implementation and compliance monitoring for completed habitat actions to ensure that habitat improvement actions are implemented as planned.

The Action Agencies will support effectiveness monitoring related to their habitat mitigation efforts at a range of scales including the site and watershed scales. One example of effectiveness monitoring is BPA's continuation of project-scale action effectiveness monitoring (AEM) through funding the completion of the AEM project study design to monitor and evaluate the Action Agencies' salmon and steelhead tributary habitat improvement actions. The AEM project was developed in 2013 with program partners including; Tribes, Federal agencies, states, and non-profit organizations to establish a comprehensive, consistent, and cost effective programmatic monitoring and evaluation approach to the large number of salmon and steelhead habitat improvement actions implemented by BPA throughout the Columbia River Basin

The Action Agencies will support the completion of a summary analysis and synthesis report for the Columbia Habitat Monitoring Program to guide management decisions on habitat priorities funded by BPA. The Action Agencies will continue to support fish status and trend monitoring within the Entiat, Lemhi, and middle and upper portions of the John Day basins.

1.3.7 Research

The Action Agencies intend to articulate future research priorities consistent with regional critical uncertainties within the forthcoming tributary habitat RME strategy. The Action Agencies will fund fish and habitat research projects with regional partners following collaboration with NMFS and when necessary to inform management decisions. Also, to address the continued uncertainty around the biological effects of increased spill associated with the proposed action, the Action Agencies may implement a study (or studies) to test the biological effects of increased spill. Accordingly, the Action Agencies will work with NMFS and other interested regional sovereigns to develop and implement a test of the relative influence of system operations on any direct or indirect effects on juvenile salmon and steelhead passage, survival, and condition and adult passage delay, fallback, and re-ascension.

1.3.7.1 Juvenile Salmonid Monitoring

The Action Agencies propose to implement the following juvenile fish monitoring actions:

- Continue to annually fund and implement the SMP.
- Continue to implement and maintain the Columbia River Basin Passive Integrated Transponder Information System (PTAGIS).
- Implement improvements to PIT detection capability to support the development of in-river juvenile salmon and steelhead survival estimates with specific improvements at or near Bonneville Dam.
- Further investigate juvenile fish survival if additional needs are developed through the Adaptive Implementation of the Flexible Spill Operation Process (Appendix X in BPA et al. 2020).

1.3.7.2 Adult Salmonid Monitoring

The Action Agencies propose to implement the following adult fish monitoring actions:

- Visually count and report adult salmon, steelhead, and bull trout passage. In addition to reporting net upstream passage, the Corps will report the presence of bull trout in fish count windows to ensure the relatively rare sightings are recorded.

- Maintain PIT detection capability in adult fishways as needed to support monitoring of adult survival through fishway re-ascension rates
- Monitor adult ladder counts and PIT-based re-ascension rates to identify any potential delay or fallback issues associated with temperatures in the exit sections of fishways.
- Monitor pinniped activity at Bonneville Dam, consistent with the monitoring plan to be developed in coordination with NMFS.
- Provide ongoing cost share to research the effects of nearshore ocean conditions on adult returns.
- Further investigate adult fish survival if additional needs are developed through the Adaptive Implementation of the Flexible Spill Operation Process (Section 2.3.2.6 in BPA et al. 2020; and DEIS Appendix R [Part 2] in USACE et al. 2020).

1.3.7.3 Shad Deterrence

The Corps will investigate the feasibility of deterring adult shad from approaching and entering the Lower Granite Dam adult fish trap, alleviating the need to remove shad from the trap while processing adult salmon and steelhead, and thereby reducing stress and delay for ESA-listed target species. Measures for consideration will be developed in coordination with NMFS and may include acoustic deterrents and operational changes, such as instituting plunging flows or blocking overflow weirs.

1.3.7.4 Off-season Surface Spill for Downstream Passage of Adult Steelhead

Each year, a portion of MCR steelhead migrate upstream past McNary Dam, overshooting natal tributaries. These fish then migrate back downstream through McNary Dam during months when there is no scheduled juvenile fish passage spill. In fall 2019, the Corps began an initial evaluation of off-season surface spill (24 hours per week) as a means of providing safe and effective downstream passage for adult steelhead and other fish at McNary Dam. The Corps will continue to refine and implement a multi-year evaluation to determine the frequency, timing, and duration of the off-season surface spill needed to effectively pass adult steelhead downstream of McNary Dam. Pending results of the evaluation, the Action Agencies will, in coordination with NMFS, develop and implement an off-season surface spill operation at McNary Dam. The Corps will use existing information and, if warranted, targeted studies to determine whether other lower Columbia or lower Snake River dams should be considered for similar offseason surface spill operations. The Action Agencies may also investigate potential structural modifications to spillway weirs that would allow reduced off-season spill volumes, while providing effective and safe passage of adult steelhead.

1.3.7.5 Biological Testing of Improved Fish Passage Turbines and Screen Deployment Cessation

In 2019, the Corps funded a study at Ice Harbor Dam’s Unit 2 (an IFP turbine unit outfitted with fixed blades) to estimate direct injury and survival of juvenile Chinook salmon passing through the new turbine runner. As additional turbine unit runners are replaced at Ice Harbor, McNary, and John Day Dams, the Corps may need to conduct additional direct injury and survival studies or other evaluations to inform turbine designs and verify their biological effectiveness. Particular study objectives and needs would be developed with NMFS, USFWS, and other regional sovereigns through the Studies Review Work Group.

The Action Agencies propose consideration of cessation of deployment of turbine intake bypass screens at Ice Harbor, McNary, and John Day Dams following replacement of existing turbine unit runners with new IFP designs. In addition to further coordination with NMFS, the Action Agencies agree that any proposed changes in the configurations or operations at these dams requires biological monitoring and evaluations. If the study results demonstrate a neutral or beneficial effect, and NMFS concurs, the Action Agencies will consider cessation of turbine intake bypass screen installation. The Action Agencies anticipate that acoustic telemetry studies (beginning with Ice Harbor Dam) would be needed to evaluate dam passage and survival. Additionally, the Action Agencies may need to conduct biological studies to assess the effects on adult salmon and steelhead passage through JBSs and impacts on the SMP, as well as PIT-based system survival analyses. Particular study objectives and needs would be developed with NMFS, USFWS, and other regional sovereigns through the Studies Review Work Group.

1.3.7.6 Adult Salmon and Steelhead Passage Response to Pacific Lamprey Modifications

As proposed adult Pacific lamprey passage improvements are implemented, radio-telemetry, video, or acoustic imaging studies may be needed to verify that structural or operational changes have a neutral to beneficial effect on adult salmon and steelhead. Particular study objectives and needs would be developed with NMFS, USFWS, and other regional sovereigns through the Studies Review Work Group.

1.3.8 Reporting, Adaptive Management, and Regional Coordination

The Action Agencies propose to use the best available scientific information to identify and carry out actions that are expected to provide immediate and long-term benefits to listed fish, while continuing to operate for other authorized purposes set forth by Congress. To that end, the Action Agencies propose to coordinate with NMFS and other regional partners to inform and signal appropriate adaptations to changing circumstances (see the BA, Section 2.7, for details [BPA et al. 2020]).

1.3.8.1 Annual Biological Opinion Implementation Reporting

The Action Agencies propose to report annually to NMFS the following information:

- Configuration or operational changes at the dams.
- Operations for juvenile fish (e.g., the placement of screens, the start and end of spill operations).
- Transport operations (start and end of transport operations, number of fish transported).
- Operations for adult fish.

- Predation management actions.
- Results from monitoring operations, such as:
  - Adult fish counts.
  - Pinniped numbers and predation estimates at Bonneville Dam.
  - Juvenile fish in-river system survival estimates.
  - Adult fish upstream conversion estimates.[13]
- Tributary habitat improvements:
  - See the proposed action, Section 2.6.1.4 (Tributary Habitat Reporting and Evaluation) for details on tributary habitat improvement reporting.
- Estuary habitat improvements:
  - Acres of estuary floodplain improved.
  - Miles of estuary riparian area improved.

1.3.8.2 Adaptive Management and Regional Coordination

The Action Agencies propose to continue to use an adaptive management framework to manage system operations and guide implementation of the additional non-operational measures to benefit ESA-listed salmon and steelhead. The Action Agencies propose to continue to work collaboratively with regional sovereign parties to adaptively manage the implementation of system operations related to fish through various policy and technical teams, collectively referred to as the Regional Forum,[14] and to implement year-round system operations related to fish and adaptively manage operations, as necessary.

The process for adaptive management of the flexible spill component of the CRS operations (AIF) is attached to the DEIS Appendix R (Part 2), released on February 28, 2020, for public review and comment. This AIF appended to the DEIS replaces the previous draft version shared with the Services on January 23, 2020.

During the 2020 spring spill season, the first year when some dams spilled at 125 percent TDG gas cap spill, GBT monitoring of juvenile salmonids continued using the primary established protocols. In this protocol, the unpaired fins and eyes are examined for the presence of bubbles and the area covered with bubbles is quantified at five of the Columbia River System dams

[13] NMFS has historically produced estimates of juvenile in-river system survival and adult fish conversion rates. The Action Agencies provide tagged fish, detection capability at dams, and maintain the PITagis database, while NOAA analyzes the data, generates the estimates and delivers them to the Action Agencies for inclusion in annual Biological Opinion reporting. The Action Agencies assume this collaborative arrangement will continue.

[14] This includes the Regional Implementation Oversight Group (RIOG) and may include the Flexible Spill Working Group (FSWG), a subset of the RIOG; Technical Management Team (TMT); Systems Configuration Team (SCT); Studies Review Work Group (SRWG); Fish Facility Design Review Work Group (FFDRWG); and Fish Passage Operations and Maintenance (FPOM) coordination team.

(Lower Granite, Little Goose, Lower Monumental, McNary and Bonneville Dams). Native non-salmonid fish collected in the JBSs are monitored using the same methods applied to salmonids. The data are reported to fisheries management entities and the water quality agencies of Washington and Oregon on a daily basis. The data are made available to other interested parties through FPC weekly reports and when postings are made to the FPC web site during the season. The 2020 sampling methodologies and data collected will be used to develop biological monitoring plans required for the 2021 spring spill season.

1.3.8.3 Contingencies

The Action Agencies propose to continue to utilize adaptive management principles in implementing the Proposed Action (BPA et al. 2020). Actions such as spill, bypass, and transport operations at mainstem Snake and Columbia River projects will be adaptively managed annually based on results of biological studies and monitoring information. These results will be discussed, and operations modified in collaboration with federal state and tribal sovereigns through the Regional Forum, to ensure expected benefits to salmon and steelhead are being met based on the best available scientific information.

The Action Agencies propose to continue relying upon annual species status monitoring results (summarized by NMFS) to inform Regional Forum discussions and adaptive management decisions. The Action Agencies do not propose to use specific abundance or trend triggers as previously set forth in the 2009 Adaptive Management Implementation Plan (USACE et al. 2009) because they have become outdated (e.g., they were based on adult returns through 2007 or 2008), because many identified contingency actions are already being implemented (e.g., substantially higher spill levels due to the proposed flexible spill operation, refined transportation operations, hatchery reform, etc.), and because several contingency actions (e.g., reducing harvest, some elements of predator control, etc.) were outside their authority to implement. Instead, they propose to work with NMFS, USFWS, federal, state and tribal sovereigns and other appropriate parties in any region-wide diagnostic efforts to determine the causes of declines in the abundance of naturally produced salmon and steelhead and to identify and operationalize potential contingency actions should the need arise.

1.4 Action Area

“Action area” means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For this consultation, the action area for all fish species is the mainstem Columbia River, including and downstream of Libby and Hungry Horse Dams and reservoirs (on tributaries in Montana), down to and including the Columbia River estuary and plume (i.e., nearshore ocean adjacent to the river mouth); the Snake River below the confluence with the Salmon River; and the Clearwater River, including Dworshak Reservoir and downstream of the dam in the North Fork Clearwater River, flowing into the Clearwater River to its confluence with the lower Snake River. It also includes any subbasins that are the focus of the tributary habitat improvement actions that the Action Agencies have proposed to offset any residual adverse effects of system management. Further, the action area extends upstream to all accessible spawning and rearing areas of ESA-listed salmon and steelhead that are affected by the CRS action.

The downstream extent of the action area for fish species (the nearshore ocean immediately adjacent to the river mouth) is defined by observed changes in flow attributable to the operation of the CRS.

2. Endangered Species Act

This chapter describes the status of 16 different ESA-listed species and their critical habitats in the action area that could be affected by the proposed action, and describes the environmental baseline. It also provides NMFS' finding regarding the effects of the proposed action, and whether the action is likely to jeopardize the listed species or destroy or adversely modify their critical habitat.

2.1 Analytical Approach

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of the consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

This opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This opinion relies on the regulatory definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species." (50 CFR 402.02).

The designations of critical habitat for salmon, steelhead, and eulachon use the terms primary constituent elements (PCEs) or essential features. The 2016 critical habitat regulations (81 FR 7414) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44976), that definition does not change the scope of our analysis and in this opinion we use the terms “effect” and “consequences” interchangeably.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the range-wide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: 1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species, or 2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

In this opinion, we analyze each species separately because each species is uniquely exposed to the effects of the action, either in terms of life history, run timing, number of dams passed, or location in the Columbia River basin. In addition, the status of species and critical habitat can vary among species. Accordingly, our analysis of the action area, environmental baseline, effects of the action, and cumulative effects focuses on the facts and evidence most relevant to the species under review, such that our jeopardy and adverse modification analyses and conclusions for one species are independent from other species reviewed in this biological opinion.

For Pacific salmon, steelhead, and certain other species, we commonly use four “viable salmonid population” (VSP) criteria (McElhany et al. 2000) to assess the viability of the populations that, together, constitute the species. These four criteria (spatial structure, diversity, abundance, and productivity) encompass the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population’s capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment.[15]

“Spatial structure” refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population’s spatial structure depends on habitat

[15] The viable salmonid population (VSP) concept and approach was intended to “serve as the basis for a general approach to performing salmonid conservation assessments” and to “help in the establishment of Endangered Species Act (ESA) delisting goals” (McElhany et al. 2000).

quality and spatial configuration, and the dynamics and dispersal characteristics of individuals in the population.

"Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation in single genes to complex life-history traits (McElhany et al. 2000).

"Abundance" generally refers to the number of naturally produced adults (i.e., the progeny of naturally spawning parents) in the natural environment (e.g., on spawning grounds).

"Productivity," as applied to viability factors, refers to the entire life cycle (i.e., the number of naturally spawning adults produced per parent). When progeny replace or exceed the number of parents over time, a population is stable or increasing. When progeny fail to replace the number of parents over time, the population is declining. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species' populations has been determined, we assess the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, and ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000).

The proposed action is the preferred alternative identified in the CRSO DEIS (USACE et al. 2020), that assesses and updates the approach for longer-term system operations, maintenance, and configuration, as well as evaluates measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[16]

We analyze the effects of the proposed action in the interior Columbia River basin using the COMPASS (Comprehensive Passage Model) model to assess effects on juvenile survival migrating through the lower Snake and Columbia Rivers. The COMPASS model was developed by NMFS' Northwest Fisheries Science Center (NWFSC) and is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of salmon and steelhead. Information from both PIT tags and acoustic tags were

[16] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the DEIS in February 2020, the Final EIS in July 2020 and Records of Decision by September 30, 2020.

used to calibrate the model. This model has been specifically developed for Snake River spring-summer Chinook salmon, Snake River steelhead, UCR spring-run Chinook salmon, and UCR steelhead. Model results are designed to be directly applicable to these species, and can be used as a surrogate to assess effects [17]on other, related species with similar life-histories (e.g., Middle Columbia River steelhead, Lower Columbia River Chinook salmon, etc.) (Zabel and Jordan 2020).[18]

The COMPASS run results (and related life-cycle model outputs) are not directly comparable between this opinion and the analyses performed on the Preferred Alternative of the CRSO DEIS (USACE et al. 2020). COMPASS modeling of the Preferred Alternative in the DEIS used average daily spill estimates to support multiple modeling efforts. Because the modeling efforts for the DEIS were utilized to assess relative changes between the No Action Alternative and the Multiple Objective alternatives, any difference resulting from daily spill estimates versus hourly would not have changed the relative magnitude of the effects of the Multiple Objective alternatives compared to the No Action Alternative. In contrast, for this opinion, the COMPASS model was specifically modified so that it could better simulate the complex changes in spill prescribed by the flexible spill plan within each daily period. The action agencies were asked by NMFS to model spill on a 1-hour timestep so that the COMPASS model could more accurately replicate the flexible spring spill operation specified in the proposed action. So, the COMPASS results in this opinion reflect two four-hour blocks of performance level spill occurring each day (at the appropriate projects) and intervening blocks of spill up to the estimated 125 percent TDG limits (again, at the appropriate projects). Because fish bypass and spill passage efficiencies are not linearly related to spill and can differ between daytime and nighttime, results differ when modeling variable spill levels within each 24-hour period compared to modelling overall average daily spill levels.[19]

One notable difference is that estimates of juvenile bypass passage rate from the more refined modeling of the flexible spring spill operation presented in this opinion are consistently higher than model estimates presented in the CRSO Draft EIS. This difference results in increased estimates of the number of juveniles collected for transportation in this opinion relative to estimates in the CRSO Draft EIS.

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[17] Both the COMPASS/Life Cycle and CSS models used in the EIS were reviewed by Battelle (2020).

[18] The Comparative Survival Study (CSS) model is a more generalized model that does not rely upon route-specific passage and survival rates, but instead uses correlations (e.g., indexes of powerhouse passage events) to predict juvenile reach survival rates and smolt to adult return rates. Both the COMPASS and CSS models rely upon relationships developed with environmental parameters (e.g., spill levels) that have been observed in past years. As such, model results using environmental parameters extrapolated beyond the range of existing data (e.g., high spill, low flow years) could be erroneous, if the actual relationships between independent and dependent parameters differ from those assumed in the models.

[19] This does not imply that the COMPASS modeling in the CRSO DEIS is in any way inadequate. Indeed, using different time steps (e.g., daily versus hourly) for the many different comparative models (COMPASS and others) used in the CRSO DEIS would cause confusion with respect to comparing the outcomes of the alternatives considered. The COMPASS results in this opinion are simply more refined (using hourly, not daily, time steps).

We use life-cycle models developed by the NWFSC to project estimates of population abundance and a quasi-extinction risk (QET) for 20 populations of Snake River spring/summer Chinook salmon and one population (Wenatchee River) of Upper Columbia River spring-run Chinook salmon.[20] The life-cycle models incorporate results from the COMPASS model and are parameterized to include tributary habitat actions, pinniped predation, and survival in the ocean. The life-cycle models, which are under continuing refinement, are useful to inform our analyses (ISAB 2006a, 2006b, 2006c, 2008, 2013, 2017). We also use the life-cycle models to assess the potential effect of increases in productivity (smolt to adult returns) that the Comparative Survival Study hypothesizes will result from the proposed flexible spring spill operation increasing the proportion of juvenile Snake River spring/summer Chinook and steelhead that pass dams via the spillways and decreasing the proportion of juveniles passing via the powerhouses (passage through turbines or screened bypass systems). Additional, species-specific details, are provided in the following SR spring/summer Chinook salmon (2.2.3.1.12) and UCR spring Chinook salmon (2.6.3.1.12) sections. Because they are more conservative, only quasi-extinction threshold (QET) 50 results (when projected abundance falls below 50 adult spawners for four consecutive years) are presented in the SR spring/summer Chinook salmon and UCR spring Chinook salmon chapters. Values for both QET 30 and QET 50 are presented in the Life Cycle Modeling Results appendix (Appendix C).

In addition, the U.S. Geological Survey, Western Fisheries Research Center (USGS) in coordination with the NWFSC, has recently developed a life-cycle model for Snake River fall Chinook salmon to assess the effect of proposed hydropower system operations, the effect of continuing hatchery production (in accordance with the most recent HGMPs), and the effect of recent, seasonally variable increases in sea lion predation in the lower Columbia River from the mouth to Bonneville Dam (Perry et al. 2020). Preliminary results from that model are also presented as estimates of population abundance and quasi-extinction risk that are used to inform our analysis for Snake River fall Chinook salmon. Additional details are provided in the SR fall Chinook salmon (2.5.3.1.10) section.

Life cycle-model projections for the proposed action represent relatively recent climate conditions; data from the past 20 or so years were used to calibrate the models. The life-cycle models were also used by the NWFSC to conduct a sensitivity analysis for the potential effects of climate change (both in the freshwater and marine environments) on model projections. The results of the climate change analysis using the Representative Concentration Pathway (RCP) 8.5 emissions scenario, which represents a future that could be consistent with little or no climate change mitigation policies (Terando et al. 2020), are presented in the Snake River spring/summer Chinook salmon section (2.2.3.1.12). The RCP4.5 scenario is described as an intermediate scenario that assumes, among other things, that carbon dioxide emissions start declining by 2045. Within the 24-year timeframe examined in this biological opinion, there was substantial overlap between the results of these two scenarios. This is because the predicted outcomes from the two

[20] In the future, as sufficient population-specific data becomes available, the NWFSC plans to develop life-cycle models for some Snake River, Upper Columbia River, and Middle Columbia River steelhead populations, and, potentially, for populations representing other ESUs and DPSs.

scenarios generally do not begin to differ substantially until after 2045. Considering the substantial overlap, only RCP8.5 results, the slightly more conservative scenario, are presented in detail in the Snake River spring/summer Chinook salmon chapter. Values for both RCP4.5 and RCP8.5 are presented in the Life-Cycle Modeling Results appendix (Appendix C). While the NWFSC was only able to conduct climate sensitivity modeling for SR spring/summer Chinook salmon, the results should generally be applicable to other "stream type" Chinook salmon populations in the Columbia River Basin.

2.2 Snake River (SR) Spring/Summer Chinook Salmon

This section applies the analytical framework described in Section 2.1 to the SR spring/summer Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the SR spring/summer Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.2.1 Rangewide Status of the Species and Critical Habitat

The status of the SR spring/summer Chinook salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.2.1.1 Status of the Species

2.2.1.1.1 Background

On June 3, 1992, NMFS listed the SR spring/summer-run Chinook salmon ESU as a threatened species (57 FR 23458). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160), and again on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that the ESU should retain its threatened status (81 FR 33468). Critical habitat was originally designated on December 28, 1993 (58 FR 68543), then updated on October 25, 1999 (65 FR 57399). The summary that follows describes the rangewide status of SR spring/summer Chinook salmon. Additional information can be found in the recovery plan (NMFS 2017a) and most recent status review (NMFS 2016b) for this species.[21]

The SR spring/summer-run Chinook salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon originating from the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins. The ESU includes 28 extant natural populations (plus three functionally extirpated populations and one extirpated population), which are aggregated into five MPGs based on genetic, environmental, and life-history characteristics. Eleven artificial propagation programs are also included in the

[21] In addition, a technical memo prepared for the status review contains more detailed information on the biological status of the species (NWFSC 2015).

ESU (NMFS 2017a, 70 FR 37160).[22] Figure 2.2-1 shows a map of the ESU and its component MPGs; Table 2.2-1 lists the populations within each MPG and the hatchery programs that are part of the ESU. Historically, SR spring/summer Chinook salmon also spawned and reared in several areas that are no longer accessible in the Clearwater River basin and in the area above Hells Canyon Dam.

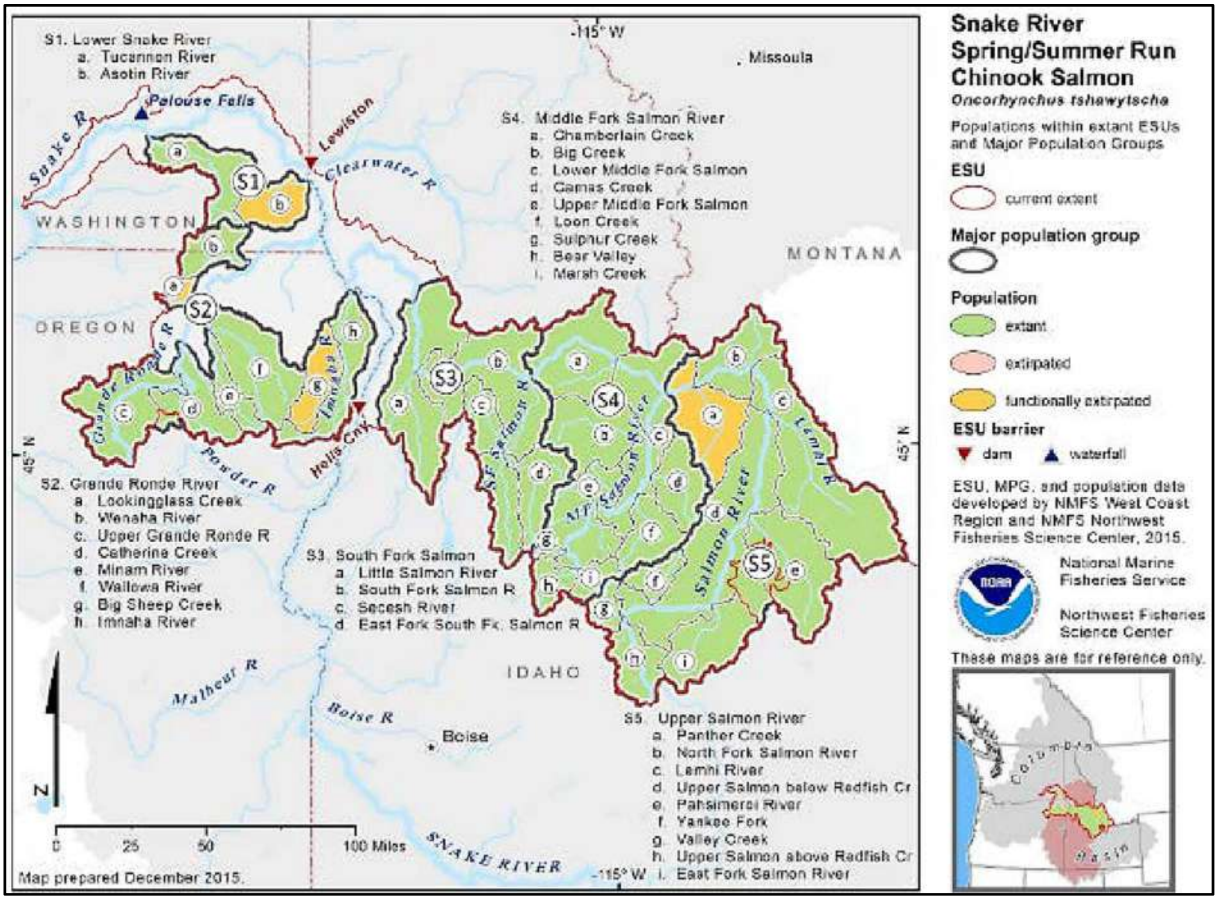

Figure 2.2-1. Map illustrating SR spring/summer Chinook salmon ESU's populations and major population groups (NWFSC 2015).

[22] For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including SR spring/summer Chinook salmon (81 FR 72759). The proposed changes for hatchery program inclusion in this ESU were to add the Yankee Fork Program, the Dollar Creek Program, and the Panther Creek Program. We expect to publish the final revisions in 2020.

Table 2.2-1. SR spring/summer Chinook salmon ESU major population groups and component populations, and hatchery programs (NMFS 2017a, 70 FR 37160).

Major Population Group	***Populations***
Lower Snake River	Tucannon River Asotin Creek (functionally extirpated)
Grande Ronde/Imnaha River	Wenaha River Lostine/Wallowa Rivers Minam River Catherine Creek Upper Grande Ronde River Imnaha River Lookingglass Creek (functionally extirpated) Big Sheep Creek (functionally extirpated)
South Fork Salmon River	Secesh River East Fork South Fork Salmon River South Fork Salmon River Mainstem Little Salmon River
Middle Fork Salmon River	Bear Valley Marsh Creek Sulphur Creek Loon Creek Camas Creek Big Creek Chamberlain Creek Lower Middle Fork Salmon Upper Middle Fork Salmon
Upper Salmon	Lower Salmon River Lemhi River Pahsimeroi River Upper Salmon River East Fork Salmon River Valley Creek Yankee Fork North Fork Salmon River Panther Creek (extirpated)
Hatchery Programs	
Hatchery programs included in ESU	Tucannon River Lostine River Catherine Creek Lookingglass Hatchery Reintroduction Upper Grande Ronde Imnaha River Big Sheep Creek McCall Hatchery Johnson Creek Artificial Propagation Enhancement Pahsimeroi Hatchery Sawtooth Hatchery

2.2.1.1.2 Life-History and Factors for Decline

SR spring/summer Chinook salmon generally exhibit a stream-type life-history, meaning that they reside in freshwater for a year or more before migrating toward the ocean, although some populations exhibit variations from this pattern (e.g., Salmon River basin juveniles may spend less than 1 year in freshwater) (Copeland and Venditti 2009). Juvenile outmigrants generally pass downstream of Bonneville Dam from late April through early June. Yearling outmigrants are thought to spend relatively little time in the estuary compared to sub-yearling ocean-type fish, often travelling from Bonneville Dam (river mile [RM] 146) to a sampling site at RM 43 in 1 to 2 days. Adult SR spring-run Chinook salmon return to the Columbia River in early spring and pass Bonneville Dam beginning in early March through late May. Adult SR summer-run Chinook salmon return to the Columbia River from June through July. Adults from both runs hold in deep pools in the mainstem Columbia and Snake Rivers and the lower ends of the spawning tributaries until late summer, when they migrate into the higher elevation spawning reaches (NMFS 2017a).

Historically, the entire Snake River basin is thought to have produced more than 1 million adult spring/summer Chinook salmon in some years (ISAB 2015, NMFS 2017a). By the 1950s, abundance of SR spring/summer Chinook salmon had declined to an estimated annual average of 125,000 adults (Matthews and Waples 1991). Declines continued, reaching a low of only about 2,200 adults (hatchery and natural-origin combined) in 1995, shortly after the ESA listing. Over the long term, abundance has been affected by a variety of factors, including ocean conditions, harvest, increased predation, construction and continued operation of Snake and Columbia River dams, adverse impacts of hatchery fish, and widespread alteration of spawning and rearing habitats (NMFS 2017a).

Harvest rates soared in the late 1800s and remained high until the 1970s. At the same time, increased European-American settlement resulted in the deterioration of habitat conditions due to logging, mining, grazing, farming, irrigation, development, and other land use practices that cumulatively reduced access to and productivity of spawning and rearing habitat, increased sediment contributions to streams, reduced instream flows, and increased stream temperatures (NMFS 2017a).

Large portions of historical habitat were blocked in 1901 by the construction of Swan Falls Dam, on the Snake River, and later by construction of the three-dam Hells Canyon Complex from 1955 to 1967. Dam construction also blocked and/or hindered fish access to historical habitat in the Clearwater River basin as a result of the construction of Lewiston Dam (removed in 1973 but believed to have caused the extirpation of native Chinook salmon in that subbasin). The loss of this historical habitat substantially reduced the spatial structure of this species. The production of SR spring/summer Chinook salmon was further affected by the development of the eight Federal dams and reservoirs in the mainstem lower Columbia/Snake River migration corridor between the late 1930s and early 1970s; four on the lower Columbia River (Bonneville, The Dalles, John Day, and McNary Dams) and four on the lower Snake River (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams) (Figure 2.2-2) (NMFS 2017a).

Figure 2.2-2. All populations of SR spring/summer Chinook salmon migrate through four lower Columbia River mainstem dams (Bonneville, The Dalles, John Day and McNary Dams), and all except one population (the Tucannon) migrate through four additional dams on the lower Snake River (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams). The Tucannon population migrates through six dams (the four lower Columbia River mainstem dams and two lower Snake River dams. (Modified from a map obtained at //www.nwcouncil.org/.)

2.2.1.1.3 Recovery Plan

The ESA recovery plan for SR spring/summer Chinook salmon (NMFS 2017a) includes delisting criteria for the ESU, along with identification of factors currently limiting the recovery of the ESU, and management actions necessary for recovery. The biological delisting criteria are based on recommendations by the Interior Columbia Basin Technical Recovery Team (ICTRT).[23] They are hierarchical in nature, with ESU-level criteria based on the status of natural-origin Chinook salmon assessed at the population level. The plan identifies ESU- and MPG-level biological criteria, and within each MPG, it provides guidance on a target risk status for each population, consistent with the MPG-level criteria. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the ESU will require sufficient improvement in its abundance, productivity, spatial structure, and diversity. Table 2.2-2 summarizes the recovery plan goals and population status (as of the most recent status review) for SR spring/summer Chinook salmon.

[23] The recovery plan also includes “threats criteria” for each of the relevant listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

Table 2.2-2. Population status as of the most recent status review (NWFSC 2015, NMFS 2016b) and recovery plan target status for SR spring/summer Chinook salmon populations (NMFS 2017a).

MPG	Population	Population Status (as of 2016 status review)	Recovery Plan Proposed Target Status	ICTRT Viability Criteria Recommendations Regarding Target Status
Lower Snake	Tucannon River	high risk	highly viable	The basic ICTRT criteria would call for both populations to be restored to viable status, with one achieving highly viable status. The ICTRT recommended that recovery efforts prioritize restoring the Tucannon River to highly viable status and evaluate the potential for reintroducing production in Asotin Creek as recovery efforts progress.
	Asotin Creek	functionally extirpated	consider reintroduction	
Grande Ronde/ Imnaha	Catherine Creek	high risk	viable or highly viable	The basic ICTRT criteria call for a minimum of four populations at viable status, with at least one highly viable, and the rest meeting maintained status. The potential scenario identified by the ICTRT would include viable populations in the Imnaha River (representing important run-timing diversity), the Lostine/Wallowa River (representing a large-size population), and at least one from each of the following pairs: Catherine Creek or Upper Grande Ronde River (representing large-size populations), and Minam River or Wenaha River.
	Upper Grande Ronde River	high risk	maintained	
	Minam River	high risk	viable or highly viable	
	Wenaha River	high risk	viable or highly viable	
	Lostine/Wallowa Rivers	high risk	viable or highly viable	
	Imnaha River	high risk	viable or highly viable	
	Big Sheep Creek	functionally extirpated	consider reintroduction	
	Lookingglass Creek	functionally extirpated	consider reintroduction	
South Fork Salmon	South Fork Salmon River Mainstem	high risk	viable	The basic ICTRT criteria call for two of the populations in this MPG to be restored to viable status, with at least one of these highly viable, and the rest meeting maintained status. The ICTRT recommended that the populations in the South Fork Salmon River drainages be given priority due to the relatively small size and the high level of potential hatchery integration for the Little Salmon River population.
	Secesh River	high risk	highly viable	
	East Fork South Fork Salmon River	high risk	maintained	
	Little Salmon River	high risk	maintained	

MPG	Population	Population Status (as of 2016 status review)	Recovery Plan Proposed Target Status	ICTRT Viability Criteria Recommendations Regarding Target Status
Middle Fork Salmon	Big Creek	high risk	highly viable	The basic ICTRT criteria call for at least five of the nine populations in this MPG to be restored to viable status, with at least one demonstrating highly viable status. The remaining populations should achieve maintained status. The ICTRT example recovery scenario recommended that Chamberlain Creek (geographic position), Big Creek (large-size category), Bear Valley Creek, Marsh Creek, and either Loon Creek or Camas Creek achieve viable status.
	Bear Valley	high risk	viable	
	Marsh Creek	high risk	viable	
	Sulphur Creek	high risk	maintained	
	Camas Creek	high risk	maintained	
	Loon Creek	high risk	viable	
	Chamberlain Creek	maintained	viable	
	Lower Middle Fork Salmon River	high risk	maintained	
	Upper Middle Fork Salmon River	high risk	maintained	
Upper Salmon	Lemhi River	high risk	viable	The basic ICTRT criteria for this MPG call for at least five populations to meet viability criteria, with at least one highly viable; the rest should be maintained. The ICTRT recommendation includes restoring the Pahsimeroi River (summer Chinook life-history), the Lemhi River and Upper Salmon Mainstem River (very large-size category), the East Fork Salmon River (large-size category), and the Valley Creek populations to viable status.
	Valley Creek	high risk	viable	
	Yankee Fork	high risk	maintained	
	Upper Salmon River	high risk	highly viable	
	North Fork Salmon River	high risk	maintained	
	Lower Salmon River	high risk	maintained	
	East Fork Salmon River	high risk	viable	
	Pahsimeroi River	high risk	viable	
	Panther Creek	extirpated	reintroduction	

2.2.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within the ESU based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans, and based on recommendations of the ICTRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low risk. Generally, each MPG must achieve low risk for the ESU as a whole to be considered no longer threatened or endangered.

NMFS' most recent status review (NMFS 2016b) indicated that the SR spring/summer Chinook salmon ESU remained at high overall risk, and that all but one population in the ESU remained at high risk (the Chamberlain Creek population, in the Middle Fork Salmon River MPG, was determined in the most recent status review to have improved to an overall status of "maintained" due to an increase in abundance).[24] In the most recent status review, natural-origin abundance for most populations in the ESU had increased over the levels reported in the previous status review, although the increases were not substantial enough to change viability ratings (NWFSC 2015, NMFS 2016b). Relatively high ocean survival immediately before 2015 was a major factor in those abundance patterns.

The most recent status review found that, since the previous status review, some populations had increased in both abundance and productivity,[25] others had increased in abundance while their productivity decreased,[26] two populations had decreased in abundance and increased in productivity,[27] and one population (Loon Creek in the Middle Fork Salmon River MPG) had decreased in both abundance and productivity. There was no consistent pattern of response across populations or across MPGs (NWFSC 2015, NMFS 2016b).

Evaluation of population spatial structure in the most recent status review indicated that most populations remained at low or moderate risk for that parameter. Four populations (Catherine Creek and Upper Grande Ronde, in the Grande Ronde/Imnaha River MPG; Lemhi River, in the Upper Salmon River MPG; and the Lower Middle Fork Salmon River population, in the Middle Fork Salmon River MPG) remained at high risk for this parameter (NWFSC 2015, NMFS 2016b).

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[24] "Maintained" population status indicates that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the ESU.

[25] Catherine Creek, Upper Grande Ronde River, Minam River, Lostine/Wallowa River, Imnaha River, Sulphur Creek, Lemhi River, Valley Creek, Upper Salmon River, East Fork Salmon River, and Pahsimeroi River.

[26] Tucannon, South Fork Salmon, East Fork South Fork Salmon, Big Creek, Bear Valley Creek, March Creek, Camas Creek, and Yankee Fork.

[27] Wenaha and Lower Salmon River populations.

Evaluation of diversity for this ESU indicated that three MPGs have populations that are being supplemented with local broodstock hatchery programs. In most cases, those programs evolved from mitigation efforts and include some form of sliding-scale management guidelines that limit hatchery contribution to natural spawning based on the abundance of natural-origin fish returning to spawn—the more natural-origin fish that return, the fewer hatchery fish are needed to spawn naturally. Sliding-scale management is designed to maximize hatchery benefits in low abundance years and reduce hatchery risks at higher spawning levels. Most populations in the ESU were rated at low to moderate risk for diversity except for the Yankee Fork, East Fork Salmon River, and Pahsimeroi River populations, which were rated at high risk for this parameter (NWFSC 2015, NMFS 2016b).

Overall, while the most recent status review found improvements in the abundance/productivity in multiple populations (as of 2014 adult returns) relative to prior reviews, those changes were not sufficient to warrant a change in ESU status. All extant populations (except Chamberlain Creek) still faced a high risk of extinction (NWFSC 2015, NMFS 2016b). There is a considerable range in the relative improvements in life-cycle survivals or limiting life-stage capacities required to attain viable status for the populations in the ESU. In general, populations within the South Fork Salmon River MPG are the closest to viability among the MPGs. The other multiple-population MPGs each have a range of viability (NWFSC 2015, NMFS 2016b).

Table 2.2-3 lists the MPGs and populations in this ESU and summarizes their abundance/ productivity, spatial structure, diversity, and overall population risk status, based on information in the most recent status review (NWFSC 2015, NMFS 2016b).

Table 2.2-3. SR spring/summer Chinook salmon population-level risk for abundance/productivity (A/P), diversity, and integrated spatial structure/diversity (SS/D) and overall status as of the most recent status review (NWFSC 2015, NMFS 2016b). Risk ratings ranged from very low (VL), to low (L), moderate (M), high (H), very high (VH), functionally extirpated (FE), and extirpated (E). Shaded populations are the most likely combinations within each MPG to be improved to viable status. "Maintained" (MT) population status indicates that the population does not meet the criteria for a viable (low risk) population but does support ecological functions and preserve options for recovery of the ESU.

Major Population Group	Population	ICTRT Minimum Abundance Threshold[1]	A/P Risk Rating	Diversity Risk Rating	Integrated SS/D Risk Rating	Overall Extinction Risk Rating
Lower Snake	Tucannon River	750	H	M	M	H
	Asotin Creek	500	FE	FE	FE	FE
Grande Ronde/ Imnaha	Catherine Creek	1,000	H	M	M	H
	Upper Grande Ronde River	1,000	H	M	H	H
	Minam River	750	H (M)	M	M	H
	Wenaha River	750	H	M	M	H

Major Population Group	Population	ICTRT Minimum Abundance Threshold[1]	A/P Risk Rating	Diversity Risk Rating	Integrated SS/D Risk Rating	Overall Extinction Risk Rating
	Lostine/Wallowa Rivers	1,000	H	M	M	H
	Imnaha River	750	H (M)	M	M	H
	Big Sheep Creek	500	FE	FE	FE	FE
	Lookingglass Creek	500	FE	FE	FE	FE
South Fork Salmon	South Fork Salmon River	1,000	H (M)	M	M	H
	Secesh River	750	H (M)	L	L	H
	E Fork S Fork Salmon River	1,000	H	L	L	H
	Little Salmon River	750	Insufficient data	L	L	H
Middle Fork Salmon	Big Creek	1,000	H	M	M	H
	Bear Valley Creek	750	H (M)	L	L	H
	Marsh Creek	500	H	L	L	H
	Sulphur Creek	500	H	M	M	H
	Camas Creek	500	H	M	M	H
	Loon Creek	500	H	M	M	H
	Chamberlain Creek	750	M	L	L	MT
	Lower Mainstem Middle Fork Salmon River	500	Insufficient data	M	M	H
	Upper Mainstem Middle Fork Salmon River	750	H	M	M	H
	Lemhi River	2,000	H	H	H	H

Major Population Group	Population	ICTRT Minimum Abundance Threshold[1]	A/P Risk Rating	Diversity Risk Rating	Integrated SS/D Risk Rating	Overall Extinction Risk Rating
Upper Salmon	Valley Creek	500	H	M	M	H
	Yankee Fork	500	H	H	H	H
	Upper Salmon River	1,000	H (M)	L	L	H
	North Fork Salmon River	500	Insufficient data	L	L	H
	Lower Salmon River	2,000	H	L	L	H
	East Fork Salmon River	1,000	H	H	H	H
	Pahsimeroi River	1,000	H (M)	H	H	H
	Panther Creek	750	E	E	E	E

[1]Minimum abundance thresholds represent the number of spawners needed for a population of a given size category to achieve low risk (viability) at a given productivity (ICTRT 2007).

2.2.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the SR spring/summer Chinook salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. Limiting factors identified in the recovery plan (NMFS 2017a) for this ESU include (in no particular order):

- Tributary habitat degradation: Past and/or present land use hinders SR spring/summer Chinook salmon productivity through the following limiting factors: impaired fish passage (e.g., culverts, water diversions, and weirs at hatchery facilities); reduced stream complexity and channel structure; excess fine sediment; elevated summer water temperatures; diminished streamflow during critical periods; reduced floodplain connectivity and function; and degraded riparian conditions.
- Estuarine habitat degradation: Past and current land use (including dredging, filling, diking, and channelizing of lower Columbia River tributaries) and alterations to Columbia River flow regimes by reservoir storage and release operations have reduced the quality and quantity of estuarine habitat.
- Hydropower: Federal hydropower projects in the lower Snake and Columbia River mainstem affect juvenile and adult SR spring/summer Chinook salmon, which must pass up to eight mainstem dams. The fish are also affected to a lesser degree by the management of water released from the Hells Canyon Complex on the middle Snake

River, Dworshak Dam on the North Fork Clearwater River, and other projects, including upper basin storage reservoirs in the U.S. and Canada. Limiting factors include those related to dam passage mortality; loss of habitat due to conversion of riverine habitat to slower moving reservoirs with modified shorelines; and changes in temperature regimes due to flow modifications in all mainstem reaches.

- Harvest: Direct and indirect effects associated with past and present fisheries continue to affect the abundance, productivity, and diversity of SR spring/summer Chinook salmon. However, while harvest-related mortality contributed significantly to the species' decline, harvest impacts have been reduced substantially and have remained relatively constant in recent years.
- Hatchery programs: Hatchery programs can improve the abundance of salmon populations with low abundance and support reintroduction into areas where they have been blocked or extirpated. However, hatchery propagation also poses risks to natural-origin salmon. These risks include genetic risks, reduced fitness, altered life-history traits, increased competition for food and habitat, amplified predation, and transferring of diseases.
- Predation: Anthropogenic changes have altered the relationships between salmonids and other fish, bird, and pinniped species. Predation by pinnipeds, birds, and piscivorous fish in the mainstem Columbia and Snake Rivers and some tributaries has increased to the point that it is a factor limiting the viability of SR spring/summer Chinook salmon.
- Additional factors include exposure to toxic contaminants, and the effects of climate change and ocean cycles.

In its most recent status review, NMFS (2016b) noted that:

- Improvements had been made in tributary and estuary habitat conditions due to restoration and protection efforts, but habitat concerns remain throughout the Snake River basin, particularly in regard to streamflow, floodplain management, and water temperature.
- Changes to hydropower operations and passage had increased juvenile survival rates.
- Hot summer temperatures and impaired migration conditions in 2013 resulted in approximately 15 percent of the migrating adult summer Chinook salmon failing to pass Lower Granite Dam. Hot summer temperatures in 2015 again led to substantial adult losses, primarily in the lower Columbia River but also in the lower Snake River.
- The adoption of the 2008 to 2017 *U.S. v. Oregon* Management Agreement had, on average, reduced impacts of freshwater fisheries to all Snake River ESUs and DPSs.
- SR spring/summer Chinook salmon hatchery production levels had remained stable since the previous review. Many captive broodstock programs initiated in the 1990s had been terminated after the status of the targeted populations improved.

- New information indicated that avian and pinniped predation on SR spring/summer Chinook salmon had increased since the previous status review.
- Regulatory mechanisms had generally improved since the previous status review.
- Uncertainty regarding the long-term impacts of climate change and the ability of SR spring/summer Chinook salmon to adapt added additional risks to species recovery.
- Key protective measures included continued releases of cool water from Dworshak Dam during late summer, continued flow augmentation to enhance flows in the lower Snake River in July and August, and continued efforts to improve adult passage at Lower Granite Dam.

2.2.1.1.6 Information on Status of the Species since the 2016 Status Review

The best scientific and commercial data available with respect to the adult abundance of SR spring/summer Chinook salmon indicate a substantial downward trend in the abundance of natural-origin spawners at the ESU level from 2014 to 2019 (Figure 2.2-3). The past 3 years (2017 through 2019) have shown the lowest returns since 1999. This recent downturn in adult abundance is thought to be driven primarily by marine environmental conditions and a decline in ocean productivity (see discussion below), because hydropower operations, the overall availability and quality of tributary and estuary habitat, and hatchery practices have been relatively constant or improving over the past 10 years.[28] Increased abundance of sea lions in the lower Columbia River could also be a contributing factor.

Population-level estimates of natural-origin and total (natural- plus hatchery-origin) spawners through 2018 are shown in Table 2.2-4. These data also show recent and substantial downward trends in abundance of natural-origin and total spawners for most of the MPGs and populations (exceptions are the Lemhi River, Camas Creek, and Upper Grande Ronde Mainstem) when compared to the 2009 to 2013 period (Table 2.2-4).[29] All populations except Chamberlain Creek remain considerably below the minimum abundance thresholds established by the ICTRT (shown in Table 2.2-3). For many populations, the total spawner counts include substantial numbers of hatchery-origin adults. Exceptions are the entirety of the Middle Fork MPG and several populations in the Upper Salmon MPG, where there are no hatchery fish included in the spawner counts.

[28] Many factors (e.g., higher summer temperatures, lower late summer flows, low spring flows, etc.) affect the ability of tributary habitat to produce juvenile migrants (capacity) each year. Recent drought and temperature patterns may have had a negative effect on tributary habitat productivity, and as a result, lower than average juvenile production may have contributed in some years to downturns in adult abundance.

[29] The upcoming status review, expected in 2021, will include population-level adult returns through 2019, and will add a new rolling 5-year geomean, for 2015 to 2019. Because the 2014 adult returns represented a peak at the ESU level, the negative percent change between the 2015–2019 and 2014–2018 geomeans will likely be greater than that shown in Table 2.2-4 between the 2014–2018 and 2009–2013 geomeans, at least for some populations.

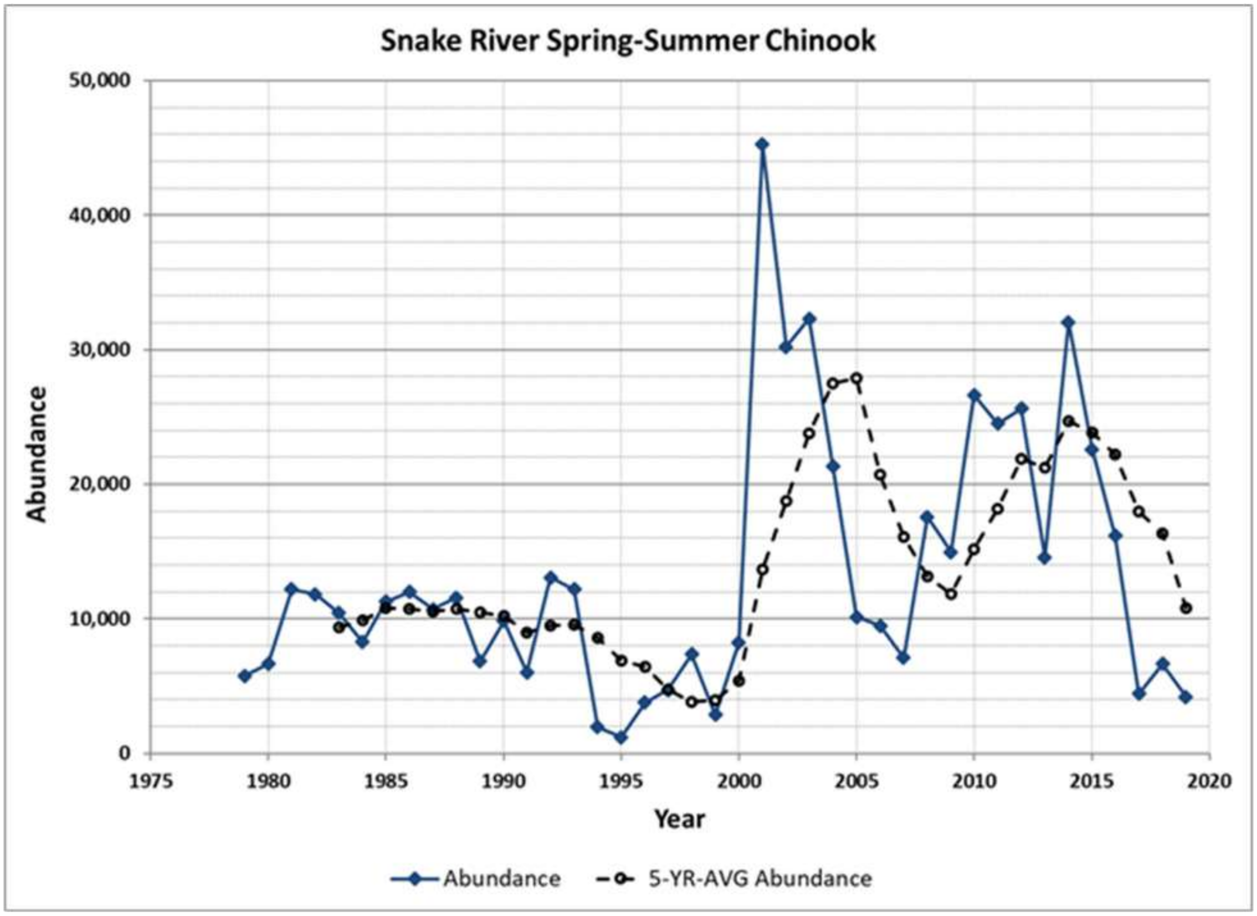

Figure 2.2-3. Annual abundance and 5-year average abundance estimates for the SR spring/summer Chinook ESU (natural-origin fish only and excluding jacks), including Lower Granite Dam passage and Tucannon River escapement estimates from 1979 to 2019. Data are from the 2020 Joint Staff Report on Stock Status and Fisheries (ODFW and WDFW 2020).

Table 2.2-4. 5-year geometric mean of natural-origin spawner counts for SR spring/summer Chinook salmon, excluding jacks. Number in parenthesis is the 5-year geometric mean of total spawner counts. "% Change" is a comparison between the two most recent 5-year periods (2014–2018 compared to 2009–2013). "NA" means not available. At the time of drafting this opinion, 2019 data were not available for any of the populations in this ESU. Source: (Williams 2020d).

Population	MPG	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change
Grande Ronde/Imnaha River	Catherine Creek	NA	40 (46)	138 (186)	51 (185)	264 (549)	112 (298)	-58 (-46)
	Upper Grande Ronde River Mainstem	NA	31 (39)	36 (37)	22 (101)	70 (459)	77 (292)	10 (-36)
	Imnaha River Mainstem	218 (468)	193 (354)	792 (1579)	227 (905)	462 (1408)	354 (840)	-23 (-40)

Population	MPG	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change
	Lostine/Wallowa Rivers	86 (206)	86 (92)	292 (374)	243 (648)	705 (1650)	427 (821)	-39 (-50)
	Minam River	172 (391)	115 (131)	413 (423)	393 (400)	572 (618)	440 (475)	-23 (-23)
	Wenaha River	77 (244)	132 (198)	384 (409)	386 (396)	409 (486)	389 (555)	-5 (14)
South Fork Salmon River	South Fork Salmon River	683 (1020)	313 (561)	829 (1308)	634 (1093)	759 (1058)	241 (615)	-68 (-42)
	East Fork South Fork Salmon River	295 (305)	136 (140)	251 (315)	119 (254)	338 (646)	317 (556)	-6 (-14)
	Secesh River	383 (392)	210 (221)	623 (644)	387 (409)	781 (798)	481 (501)	-38 (-37)
	Little Salmon River	NA	NA	NA	NA	NA	NA	NA
Middle Fork Salmon River	Bear Valley Creek	215 (215)	77 (77)	482 (482)	278 (291)	618 (618)	373 (373)	-40 (-40)
	Big Creek	119 (119)	20 (20)	207 (207)	104 (104)	257 (257)	129 (129)	-50 (-50)
	Camas Creek	33 (33)	NA	72 (72)	45 (45)	31 (31)	53 (53)	71 (71)
	Chamberlain Creek	412 (412)	69 (69)	787 (787)	468 (468)	748 (748)	693 (693)	-7 (-7)
	Loon Creek	61 (61)	NA	136 (136)	60 (60)	58 (58)	42 (42)	-28 (-28)
	Marsh Creek	156 (156)	NA	NA	110 (110)	374 (374)	311 (311)	-17 (-17)
	Upper Middle Fork Salmon River Mainstem	NA	NA	81 (81)	63 (63)	76 (76)	75 (75)	-1 (-1)
	Lower Middle Fork Salmon River Mainstem	NA	NA	NA	NA	NA	4 (4)	NA

Population	MPG	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change
	Sulphur Creek	46 (46)	NA	NA	37 (37)	71 (71)	52 (52)	-27 (-27)
Upper Salmon	East Fork Salmon River	118 (178)	22 (35)	304 (304)	238 (238)	451 (451)	285 (285)	-37 (-37)
	Lemhi River	68 (68)	35 (35)	194 (194)	68 (68)	195 (195)	273 (273)	40 (40)
	North Fork Salmon River	29 (29)	7 (7)	52 (52)	57 (57)	106 (106)	52 (52)	-51 (-51)
	Pahsimeroi River	NA	25 (34)	127 (257)	186 (290)	297 (311)	192 (382)	-35 (23)
	Lower Salmon River Mainstem	82 (82)	28 (28)	157 (157)	114 (114)	102 (102)	63 (63)	-38 (-38)
	Upper Salmon River Mainstem	308 (366)	61 (72)	443 (711)	322 (572)	517 (736)	219 (657)	-58 (-11)
	Valley Creek	34 (34)	NA	77 (77)	76 (76)	144 (144)	132 (132)	-8 (-8)
	Yankee Fork	25 (25)	NA	30 (30)	NA	117 (728)	47 (59)	-60 (-92)
Lower Snake	Tucannon River	278 (381)	60 (74)	92 (325)	225 (300)	321 (510)	84 (291)	-74 (-43)

NMFS will evaluate the implications for viability risk of these more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.2-4.

Since 2016, observations of coastal ocean conditions indicate that recent outmigrant year classes have experienced below-average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict the drop in adult Chinook salmon returns observed through 2019 (Werner et al. 2017). Some of the negative impacts on juvenile salmonids had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 50-meter surface layer) had not returned to normal (Harvey et al. 2019). Based on mainstem dam counts as of June 1, overall returns of spring Chinook salmon in 2020 also appear to be low, similar to 2019 counts. Expectations for marine survival are relatively mixed for juveniles that reached the ocean in 2019 (Zabel et al. 2020), suggesting that adult returns could increase somewhat in 2021. However, continued low jack returns as of June 1, 2020, suggest that adult numbers could remain low in 2021.

2.2.1.2 Status of Critical Habitat

NMFS designated critical habitat for SR spring/summer Chinook salmon to include all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to the Snake River confluence, as well as all river reaches of the mainstem Snake River upstream to Hells Canyon Dam (50 CFR 226.205(b)). The mainstem Columbia River and Snake River migration corridor is among the areas of high conservation value to the ESU because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults.[30] Critical habitat also includes river reaches presently or historically accessible (except those above impassable natural falls, including Napias Creek Falls, and Dworshak and Hells Canyon dams) in 17 subbasins in the interior Columbia River basin (NMFS 1993).

The PBFs identified when critical habitat was designated are essential to the conservation of SR spring/summer Chinook salmon because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). For example, the PBFs of freshwater spawning and rearing areas for SR spring/summer Chinook salmon include spawning gravel, water quality and quantity, water temperature, food, riparian vegetation, and space (Table 2.2-5).

Table 2.2-5. Physical and biological features (PBFs) of critical habitat designated for SR spring/summer Chinook salmon and corresponding species life-history events. NMFS (1993, 1999) did not identify specific areas for growth and development to adulthood in the ocean.

Physical and Biological Features (PBFs)	Component of the PBF
Spawning and juvenile rearing areas	Spawning gravel Water quality Water quantity Cover/shelter Food Riparian vegetation Space
Adult and juvenile migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food (juvenile migration corridors) Riparian vegetation Space Safe passage

[30] NMFS did not rate the conservation value of specific watersheds for this ESU as it did in subsequent designations (NMFS 2005b).

The complex life cycle of SR spring/summer Chinook salmon gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow for successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas, and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead rely on limited stored energy to migrate, mature, and spawn. Like juveniles, returning adults require cool water that is free of contaminants and migratory corridors with adequate passage conditions to allow access to the various habitats required to complete their life cycle. In the following sections, we discuss the status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary Recovery Domains.

2.2.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia Recovery Domain, which includes the Snake River basin, for SR spring/summer-run Chinook salmon. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Critical habitat throughout much of the Interior Columbia Recovery Domain has been degraded by intense agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems for critical habitat in developed areas. Restoration activities addressing tributary habitat quality and complexity, tributary and mainstem migration barriers, water quality, and excessive predation have improved the baseline condition for PBFs in some locations.

SR spring/summer Chinook salmon have lost access to large blocks of their historical habitat. Dam construction blocked or hindered fish access to historical habitat in major tributaries. In the Clearwater River basin, Lewiston Dam, which was built on the lower Clearwater River in 1927 and removed in 1973, is believed to have caused the extirpation of native Chinook salmon from areas above the dam site. In the Salmon River basin, Sunbeam Dam, constructed on the Salmon River below the mouth of the Yankee Fork (RM 368) in 1910, was a serious impediment to migration of anadromous fish and may have been a complete block in at least some years before its partial removal in 1934 (Waples et al. 1991). Many smaller dams, and some temporary dams, were also built on tributaries at this time without fish passage facilities and had the same effects, though on much smaller scales. The loss of this historical habitat significantly reduced the spatial structure that was once available to the species.

Construction of large hydropower and water storage projects associated with the CRS further affected salmonid migratory conditions and survival rates. As noted above, the production of SR spring/summer Chinook salmon was especially impacted by the development of eight major Federal dams and reservoirs in the mainstem lower Columbia/Snake River migration corridor between the late 1930s and early 1970s. Hydrosystem development also modified natural flow regimes, resulting in warmer late summer and fall water temperatures. Changes in fish communities led to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams such as turbines and juvenile bypass systems have also killed some outmigrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented improvements in the juvenile and adult migration corridors, including 24-hour volitional spill, improved surface passage routes, improved juvenile bypass systems, and predator management measures. These measures are ongoing, and their benefits related to improved functioning of the migration corridor PBFs will continue into the future.

Many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain are over-allocated, with more allocated water rights than existing stream flow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a major limiting factor for SR spring/summer Chinook salmon (NMFS 2017a).

Summer water temperatures are elevated in many tributary stream reaches across the Snake River basin and exceed water quality standards (NMFS 2017a). The elevated water temperatures restrict salmonids' use of some historically suitable habitat areas, particularly summer rearing and migration habitat. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat. They can negatively impact critical habitat and the organisms associated with these areas.

2.2.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat has also been designated for SR spring/summer Chinook salmon in the lower Columbia River estuary. For the purpose of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the

Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained the dynamic environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels; marsh and riparian habitats have been filled and diked; and causeways have been constructed that restrict the position of tributary confluences.

Over time, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of the historical variability in mainstem flows in the lower river through storage and release operations at upstream reservoirs may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has reduced the delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The combined effect of these changes is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs, and thus the conservation value of critical habitat for SR spring/summer Chinook salmon within the action area, are discussed in more detail in the Environmental Baseline section, below.

2.2.1.3 Climate Change Implications for SR Spring/Summer Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of SR spring/summer Chinook salmon and aquatic habitat is climate change. The U.S. Global Change Research Program (USGCRP)[31] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest

[31] http://www.globalchange.gov

(Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the Independent Scientific Advisory Board (ISAB)[32] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months, when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, earlier emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003, Crozier et al. 2008a, Martins et al. 2012, Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on SR spring/summer Chinook salmon include:

- Direct effects of increased water temperatures on fish physiology.
- Temperature-induced changes to stream-flow patterns, which can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.
- Alterations to freshwater, estuarine, and marine food webs, which alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity, which have changed the abundance and productivity of fish resources.

[32] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Crozier et al. (2019) assessed SR spring/summer Chinook salmon as having very high overall vulnerability to the effects of climate change based on an analysis of the ESU's sensitivity (high) and exposure (very high). Further, this ESU was determined to have high adaptive capacity (Crozier et al. 2019).[33] The high overall sensitivity rank of this ESU stemmed largely from characteristics of its migration. Negative effects of high temperatures encountered during the adult and juvenile freshwater stages have been documented (Crozier and Zabel 2006; Crozier et al. 2017a, 2017b). Populations within this ESU that migrate later, such as the Pahsimeroi and South Fork Salmon River populations, encounter stressful temperatures during their adult migration. However, both spring- and summer-run populations are at risk for prespawn mortality while holding in tributary habitats during peak summer temperatures (Bowerman et al. 2016).

This ESU was ranked very high risk for the adult freshwater stage. Because juveniles spend a full year in freshwater, they can experience negative effects on survival from warm summer temperatures and low flows (Crozier and Zabel 2006, Crozier et al. 2008b). Juvenile survival during the smolt migration depends strongly on rapid flows from snowmelt (Zabel et al. 2008, Widener et al. 2018). Thus, sensitivity in the juvenile freshwater stage was ranked high.

The Interior Columbia Recovery Domain is likely to lose a substantial portion of snowpack, so this ESU was ranked very high for hydrologic regime shift. Furthermore, exposure to stream temperature change ranked very high, elevating vulnerability to very high in both the juvenile and adult freshwater stages. A vast majority of populations in this ESU exhibit the yearling life-history strategy. Therefore, loss of this rearing strategy would mean loss of a significant characteristic of this ESU, a threat reflected in the high score for cumulative life-cycle effects. Carryover effects between life stages also increased the cumulative life-cycle effects risk, as discussed below.

SR spring/summer Chinook sensitivity was ranked moderate at the marine stage, although some scorers considered the marine mortality risk to be high. Marine survival for this ESU is lower during warm phases of the Pacific Decadal Oscillation (PDO), and rising sea surface temperature is likely to have impacts similar to the warm ocean conditions associated with both warm phases of the PDO and low adult survival (Zabel et al. 2006, Crozier et al. 2008b). On the other hand, while the smolt migration is slower in low snowpack years, earlier smolt migration timing might

[33] For additional information, see: https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results

benefit this ESU in relation to ocean upwelling (earlier ocean arrival is almost always better, but is dependent on size). At present, much of the population enters the ocean later than the optimal period for survival (Scheuerell et al. 2009). SR spring/summer Chinook have a relatively short estuary rearing period (Weitkamp et al. 2012, 2015), which resulted in low scores for estuary stage and sea level rise. Observations suggest that longer freshwater rearing produces larger smolts, which then spend less time in the estuary. Of primary concern in the cumulative life-cycle effects attribute is loss of unique life-history types, including the spring/summer adult run type and the yearling juvenile life-history strategy.

Accumulated effects from shifts in successive life stages may reduce survival in subsequent life stages. For example, earlier migration timing at the juvenile freshwater stage may mean that fish are smaller at ocean entry and less likely to encounter favorable ocean feeding conditions; smaller size is a disadvantage at ocean arrival, so if they are leaving the tributaries because they are too hot that could be a disadvantage at ocean entry. Such a timing alteration could in turn reduce early marine survival (Crozier et al. 2008a). Thus, sensitivity of this ESU was considered high for cumulative life-cycle effects.

Overall SR spring/summer Chinook salmon was ranked high in adaptive capacity. This ESU may have sufficient adaptive capacity to increase the production of subyearling smolts, or for yearling smolts to migrate earlier in spring. Adults may have some flexibility in migration timing to avoid high stream temperatures in the migration corridor. However, this would likely have a differential impact on different populations, which could ultimately reduce diversity in the basin. Early migrating adults in this ESU will still need to hold for extended periods until temperatures cool in the fall, and this will increase exposure to high stream temperatures and risk from harvest. Energetic costs during the holding period might limit adaptive capacity in the adult stage.

2.2.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima are likely to be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce fitness for salmonids, including SR spring/summer Chinook salmon (Beechie et al. 2013, Wainwright and Weitkamp 2013, Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a, Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012, Whitney et al. 2016).

2.2.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snowpack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location (Crozier et al. 2008b, Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b, Beechie et al. 2013). However, river flow is already becoming more variable in many rivers and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely that this increasingly variable flow is detrimental to multiple salmon and steelhead populations in the Columbia River basin.

The effects of climate change on stream ecosystems are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes are likely to lead to shifts in the distributions of native species and facilitate establishment of exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016, Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.2.1.3.3 Estuarine Effects

In estuarine environments, the two greatest concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013, Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010, Wainwright and Weitkamp 2013, Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006, Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species and life-history types are highly reliant on estuarine wetlands for rearing, many populations use them extensively (Jones et al. 2014). Others, such as SR spring/summer Chinook salmon, benefit from the influx of prey from the floodplain to the mainstem migration corridor (Johnson et al. 2018, PNNL and NMFS 2018, 2020).

2.2.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010, Asch 2015, Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years. For example, range extensions were documented in many species from southern California to Alaska during unusually warm water associated with the marine heatwave known as “the blob” in 2014 and 2015 (Bond et al. 2015, Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002, Fisher et al. 2015). The frequency of extreme conditions such as those associated with marine heatwaves or El Niño events is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015, Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with current models. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm-ocean conditions, suggesting that, at a minimum, prey availability and prey quality, “bottom-up” drivers of growth and survival may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem[34] (Bograd et al. 2009, Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Peterson et al. 2014, Black et al. 2015). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean (Tomaro et al. 2012), and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

[34] The California Current moves southward along the western coast of North America, beginning off southern British Columbia and ending off the southern Baja California Peninsula.

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007, Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in Alaska salmon productivity and survival (Mantua et al. 1997, Martins et al. 2012). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009, Martins et al. 2012). However, more recent information indicates that Alaska salmon, which have historically contrasted with southern populations by benefitting from warm phases of the PDO, no longer have a positive correlation with winter sea-surface temperature (Litzow et al. 2018) and are more synchronized with southern populations (Ohlberger et al. 2016). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific Ocean is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells, and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon is likely to be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015, Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.2.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change in general, including in the Pacific Northwest. The indirect effects of climate change are also uncertain, including whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013, Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is less certain, leading to a range of potential future outcomes.

2.2.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For SR spring/summer Chinook salmon, we focus our description of the environmental baseline on areas where juveniles and adults are most exposed to the effects of the proposed action. We also consider the broader action area, including tributary spawning and rearing areas, both because the Action Agencies propose to conduct habitat restoration actions in some of these subbasins and because these areas provide important context for understanding the effects of the proposed action. The area in which SR spring/summer Chinook salmon are most exposed to the effects of the proposed action includes all waters within the Columbia River from the mouth and plume[35] upstream through the lower Snake River to the head of Lower Granite Reservoir. It also includes areas in the Grande Ronde/Imnaha, Upper Salmon, and Lower Snake subbasins where SR spring/summer Chinook salmon are present and where the Action Agencies have proposed to implement habitat improvement projects.

2.2.2.1 Mainstem Habitat

Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the

[35] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

introduction of non-native species (e.g., smallmouth bass, walleye, channel catfish, and invertebrates), and other human practices that have degraded water quality and habitat.

2.2.2.1.1 Seasonal Flows

On the mainstem of the Snake[36] and Columbia Rivers, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.2-4). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

[36] The effects of the operation and maintenance of 10 Reclamation projects and two related actions in the upper Snake River above Brownlee Reservoir, including the 2004 Nez Perce Water Rights Settlement and the Snake River Water Rights Act of 2004 (for a 30-year period through 2034; USBR 2007), underwent consultation in 2008 (NMFS 2008a, 2008b).

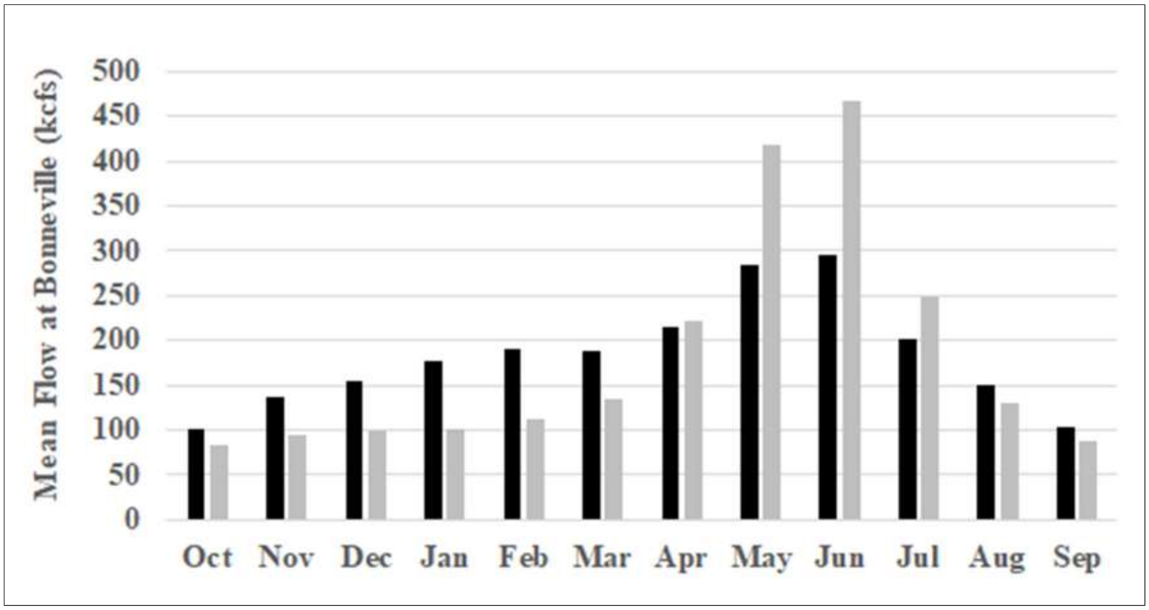

Figure 2.2-4. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[37] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs, including SR spring/summer Chinook salmon, remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year (Table 2.2-6). This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures),

[37] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile SR spring/summer Chinook salmon and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

Table 2.2-6. Seasonal flow objectives and planning dates for the mainstem Columbia and Lower Snake Rivers. NA indicates that there is not a flow objective for the season at these projects.

Location	Spring		Summer	
	Dates	Objective (kcfs)	Dates	Objective (kcfs)
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100[a]	6/21 to 8/31	50 to 55[a]
Columbia River at McNary Dam	4/10 to 6/30	220 to 260[a]	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 to 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160[b]	NA	NA

[a] Objective varies based on actual and forecasted water conditions.

[b] Objective varies according to water volume forecasts and is for chum salmon (spawning period is approximately November 1 through December and protection flow objectives are based on redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

Seasonal flow objectives for improving the migration and survival of spring and summer juvenile migrants are based on water supply forecasts; however, mean seasonal flows in the past did not always achieve the flow objectives when measured as a seasonal average flow. From 1998 to 2019, seasonal spring flow objectives were met or exceeded during 81 percent of years at McNary Dam and during 48 percent of years at Lower Granite Dam. For the years when the spring flow objectives were not met, the average seasonal flow was 88 percent of the spring flow objective at McNary Dam and 78 percent of the spring flow objective at Lower Granite Dam. Across all years, the average percentage of the spring flow objective obtained was 113 percent at McNary Dam and 101 percent at Lower Granite Dam. Achieving these seasonal flow objectives provides multiple benefits for smolts in the migration corridor, estuary, and plume. Higher spring flow helps reduce fish travel time, increases juvenile access to shallow water habitat along the river banks, increases the flux of invertebrate prey to shoreline habitat, increases turbidity (which can reduce predation on juvenile migrants), and increases the size of the Columbia River plume, which is a key transition corridor for smolts to the nearshore ocean environment. Conversely, when seasonal flow objectives are not met, juvenile survival may be reduced via these same pathways of ecological effects.

From 1998 to 2019, summer flow objectives were met or exceeded during 14 percent of years at McNary Dam and during 18 percent of years at Lower Granite Dam. For the years when the summer flow objectives were not met, the average seasonal flow was 74 percent of the summer flow objective at McNary Dam and 66 percent of the summer flow objective at Lower Granite Dam. Across all years, the average percentage of the summer flow objective obtained was 85 percent at McNary Dam and 79 percent at Lower Granite Dam. The benefits provided by attaining summer flow objectives, and potential impacts associated with not meeting them, are the same as those previously described for the spring flow objectives, but very few SR spring/summer Chinook salmon smolts are migrating at this time of year.

Recommendations on when to manage flows for the benefit of juvenile passage are made by the TMT during the juvenile migration season. These recommendations are informed by the status of the juvenile migration, water supply forecasts, river flow conditions, and river flow forecasts during the juvenile migration season.

2.2.2.1.2 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs), dichlorodiphenyltrichloroethane (DDT) and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult SR spring/summer Chinook salmon is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of SR spring/summer Chinook salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Snake and Columbia Rivers on salmon and steelhead survival is a concern; because of temperature standard exceedances, both rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges such as cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

Since the mid-1990s, the Corps has released up to 1.2 million acre-feet of cool water annually from Dworshak Dam on the North Fork Clearwater River to reduce temperatures and enhance flows in the lower Snake River from June or July to September. Operators manage water releases from Dworshak Dam so that temperatures at the tailrace of Lower Granite Dam do not exceed 68°F (20°C). This action reduces temperatures in the lower Clearwater River, and the Snake River from the confluence with the Clearwater River to at least Lower Monumental Dam, but has little to no discernible effect on temperature in the Columbia River downstream of the Snake River confluence. Even with the flow augmentation from Dworshak Dam for cooling, temperature criterion exceedances occur frequently at Little Goose, Lower Monumental, and Ice Harbor Dams from mid-July to mid-September (EPA 2020).

The releases from Dworshak Dam cool the lower Clearwater River and Lower Granite Reservoir substantially, although the cooler water is denser and sinks to the bottom, causing vertical stratification of the reservoir. As this water flows downstream, warmer surface water mixes with the cooler, deeper water as it passes through turbines and spillbays at Lower Granite Dam and each subsequent Snake River dam until the cooling effect becomes attenuated below the tailrace of Ice Harbor Dam (NMFS 2008a, 2017a). Figure 2.2-5 depicts this downstream attenuation during the high temperature conditions in 2015. Temperatures were warmest at the Anatone Gage on the Snake River upstream of Lower Granite Reservoir before it was influenced by cooler water from Dworshak Dam. Temperatures were coolest at the Peck Gage on the Clearwater River below Dworshak Dam, and tailrace temperatures proceeding downstream at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams increased at each project. Thus, even in an unusually warm, low-flow year, the cool-water releases from Dworshak Dam substantially improved the summer migration conditions for adult summer Chinook salmon in the lower Snake River compared to the high temperatures that would have been present at these projects without flow augmentation for temperature control. The difference in temperatures after mid-June observed at the Anatone Gage without the cooling effect from Dworshak Dam releases (approximately 22°C to 24°C) compared to that at Lower Granite Dam with the coldwater releases from Dworshak Dam (approximately 18°C to 21°C) is biologically significant; the Oregon and Washington temperature standards for migrating adult salmon both are 20°C (daily maximum or 7-day average daily maximum; EPA 2020), above which survival and reproductive success are expected to decline.

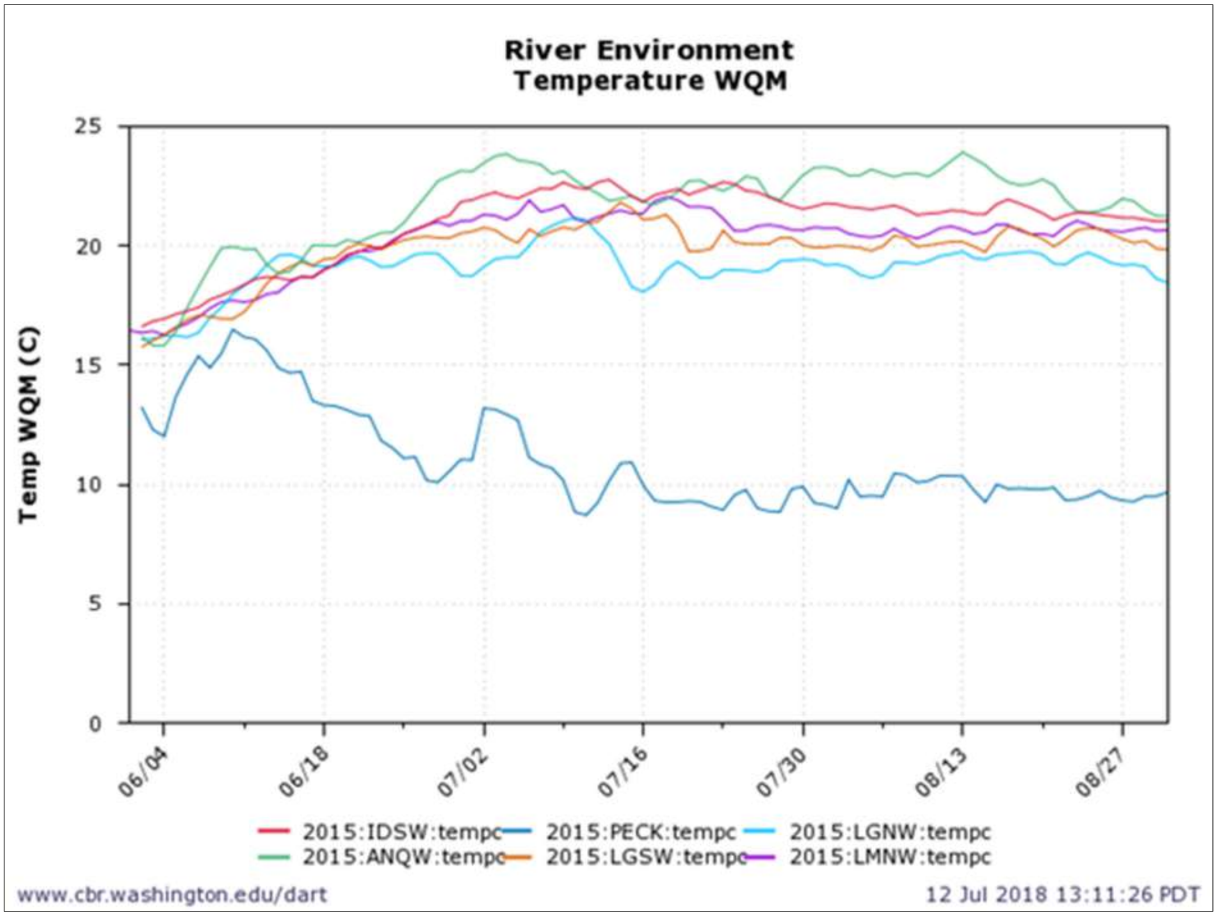

Figure 2.2-5. Water temperature at the Anatone Gage on the Snake River upstream of the Clearwater River confluence (ANQW, green); the Peck Gage on the lower Clearwater River (PECK, dark blue); and, in order from upstream to downstream located below the Clearwater River confluence, the tailrace temperatures at Lower Granite (LGNW, light blue), Little Goose (LGSW, orange), Lower Monumental (LMNW, purple), and Ice Harbor (IDSW, red) dams during summer, 2015.

The Corps also operates fishway exit cooling pumps at Lower Granite and Little Goose Dams to minimize adult passage delays associated with localized temperature differentials between these adult ladders and project forebays, which can potentially improve adult survival rates.

PIT-tag data from 2010 to 2019 (DART 2020a) indicate that 95 percent of the adults from SR spring/summer Chinook salmon populations have passed Bonneville Dam by the end of July, and in most years only a few fish migrate after August 1. It is therefore unlikely that warmer August and September mainstem temperatures would negatively affect adult SR spring/summer Chinook salmon, which have migrated into their natal tributaries by this time of year.

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the middle and lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May, 2020, EPA issued a draft total maximum daily load TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995a). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam, except The Dalles Dam. Biological monitoring (smolts sampled from the juvenile bypass systems at many mainstem dams) shows that the incidence of observed GBT in both migrating smolts and adults remains between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces.[38] When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003).[39] Under recent operations (2008 to 2019), exposure to elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June, affecting most yearling spring Chinook salmon smolts and adults. Monitoring data from 1998 to 2018 indicate that TDG did not increase instantaneous mortality rates for juvenile yearling Chinook salmon in the CRS (CSS 2019).

[38] Monitoring at the Lower Granite Dam trap in 2018 (experiencing higher court-ordered spill operations) and in 2019, showed that GBT and headburn symptoms on adult steelhead and Chinook salmon were similar in prevalence relative to past years (Corps' Lower Granite Adult Trap database accessed on December 10, 2019, and Ogden 2018b). Headburn refers to lesions and ulcers on the heads and jaws of migrating adults that can result from contact with concrete and other structures at dams, and which can increase prespawn mortality (Neitzel et al. 2004).

[39] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the Oregon Department of Environmental Quality (ODEQ) director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO # 19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

Sediment Transport

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

NMFS completed formal consultation for the Channel Maintenance Dredging in the lower Snake and Clearwater Rivers (WCR-2014-1723) on November 14, 2014. This action included dredging material in the Snake and Clearwater Rivers at four sites: 1) the downstream navigation lock approach at Ice Harbor Dam, 2) the Federal navigation channel in the Snake and Clearwater

Rivers confluence area, 3) the berthing area for the Port of Clarkston, Washington, and 4) the berthing area for the Port of Lewiston, Idaho. The Corps also issued regulatory permits for dredging at commercial ports and berths operated by local port districts or private companies in Clarkston, Washington, and Lewiston, Idaho. Most of these non-Federal navigation areas consisted of arterial channels leading from the main Federal navigation channel to the port or berth, as well as the areas at the port or berth used for loading, unloading, mooring, or turning around. During in-water work, short-term adverse effects on aquatic resources included elevated turbidity, suspension of chemicals, harassment and entrainment of fish, and disruption of benthic organisms that serve as prey for juvenile salmon. The dredged material was disposed of inriver as fill to construct a shallow-water bench for juvenile fish habitat at Knoxway Bench (RM 116) immediately upstream of Knoxway Canyon.

In 2005 to 2006, the Corps deposited approximately 420,000 cubic yards of sand and silt at the upstream end of the Knoxway Bench site. The Corps then shaped the dredged material to create an estimated 3.7-acre shallow-water habitat bench that could be used by juvenile salmonids, particularly juvenile SR fall Chinook salmon. Post-project monitoring for the 2006 effort by the Corps confirmed that juvenile salmonids have been and are using the site for resting and rearing. With the dredging conducted under the 2014 biological opinion, the materials were deposited downstream from the bench created in 2006, and extended riverward of the existing shoreline. The new material formed a uniform, gently sloping shallow-water bench along roughly 2,500 linear feet of shoreline. This feature added approximately 11.4 acres of shallow-water habitat with features preferred for foraging by juvenile salmonids—particularly fall Chinook salmon, although likely to be used by yearling Chinook as well. In sum, these activities should have little or no negative effect on juvenile or adult SR spring/summer Chinook salmon, and should increase the amount of available rearing habitat.

2.2.2.1.3 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of SR spring/summer Chinook salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[40] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted “losses” of oil or grease are tracked.

The EPA is proposing to issue National Pollutant Discharge Elimination System (NPDES) permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[41] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be “pass through” waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville), backwash strainer water on cooling water intakes. Most pollutant discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and instead result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that “will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard.” EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

“Oil and grease” in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at

[40] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[41] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river

a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 milligrams per liter [mg/L]) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.2.2.1.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adults that are migrating past the dams or within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Very few adult and juvenile SR spring/summer Chinook salmon have been affected by these activities, because they predominantly migrate from April to July and scheduled maintenance activities are typically avoided during this migration period.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult SR spring/summer Chinook salmon has likely resulted in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes have minimized the impacts.

2.2.2.1.5 Adult Migration/Survival

Adult SR spring/summer Chinook salmon migrate from the ocean, upstream through the estuary, and pass up to eight mainstem dams and reservoirs (Tucannon River population is the only population to migrate past six dams; all other populations migrate past eight dams) to reach their spawning areas. Factors that affect the survival rates of migrating adults include fish condition, harvest (either reported or unreported), dam passage (adults must find and ascend ladders and reascend the ladders if they fall back through spillways or other routes), straying (either naturally or as a result of impaired homing stemming from transport or other factors), pinniped predation, and temperature and flow conditions that can increase energetic demands of migrating fish (NMFS 2008a, Keefer et al. 2016, Keefer and Caudill 2017). Increased fallback is related to lower conversion rates to natal tributaries for adult salmonids (Keefer et al. 2005, Crozier et al. 2014).

PIT-tag detectors placed in adult ladders at the mainstem dams provide a unique ability to monitor the upstream survival of adults that were tagged as juveniles.[42] Starting with the number

[42] Using only known-origin fish adjusted for reported harvest and natural stray rates.

of adults detected at Bonneville Dam, minimum survival estimates can be derived from detections at upstream dams. Termed "conversion rates," these survival estimates are adjusted for reported harvest and the expected rate of straying of natural-origin adults. Figure 2.2-6 depicts minimum estimated survival rates from Bonneville to McNary Dams (three reservoirs and dams) and to Lower Granite Dam (seven reservoirs and dams) during 2008 to 2019, years that include recent hydropower operations and harvest rates within the "zone 6" fishery (as designated in the *U.S. v. Oregon* Management Agreements).

For adult SR spring/summer Chinook salmon that migrated inriver as juveniles, the 10-year (2010 to 2019) average minimum survival estimate for Bonneville Dam to McNary Dam is 88.9 percent (range of 81.3 to 100.0 percent; Figure 2.2-6).[43] The 10-year average minimum survival estimate for Bonneville Dam to Lower Granite Dam is 83.2 percent (range of 76.6 to 93.5 percent).

These survival estimates account for total losses from the dams and reservoirs, as well as any losses in these reaches resulting from elevated temperatures, disease, injury, or other natural causes. Expressed on a "per project" basis, about 96.1 percent of adult SR spring/summer Chinook salmon survive passage through each project (dam and reservoir) in the lower Columbia River, after accounting for reported harvest and natural stray rates. From Bonneville to Lower Granite Dams, per project survival rates average 97.4 percent. During July and August, when a portion of adult SR spring/summer Chinook migrate, solar radiation heats reservoir surface waters, which can lead to high temperatures and temperature differentials between the bottom and top sections in a fish ladder. Ladder temperatures exceeding 68°F and differentials greater than 1.8°F have been demonstrated to delay passage for Chinook salmon and steelhead at the CRS dams in the lower Snake River (Caudill et al. 2013). As temperature differentials increase, time required for passage increases; a temperature differential of 5.4°F increased the ladder passage time for summer Chinook salmon at Lower Granite Dam by a factor of 2.0 to 2.2 compared to no temperature differential. Caudill et al. (2013) noted that the increased travel time, increased thermal exposure, and related physiological stresses could reduce successful migration to natal tributaries. Ladder temperatures have commonly exceeded 68°F, and ladder differentials regularly exceeded 1.8°F while adult summer Chinook were migrating (McCann 2018). During the most extreme summer days, ladder temperatures in CRS dams have exceeded 75.0°F, and ladder differentials have exceeded 4.5°F (FPC 2019). Fish ladder–cooling structures recently installed at Little Goose and Lower Granite Dams pump colder water from deeper in the reservoir into the fish ladder and have reduced these temperature differentials. There are currently no structures to reduce ladder temperatures at the other CRS dams, but research has indicated that during the warmest months, cooler water is available near ladder exits that could be pumped into ladder exits to reduce high temperatures and ladder differentials (Lundell 2019).

[43] Conversion rates close to, or higher than, 100 percent are possible if estimates of harvest rates (or natural rates of straying) are higher than what actually occurred in a given year (biased high). Conversely, if harvest rates are underestimated, the resulting conversion rate estimates would be biased low. For this analysis, 100 percent was used as a maximum value for calculating the 10-year average survival estimate.

During 2015 when water temperatures were extremely high in the Salmon River, NMFS authorized the IDFG to trap adult SR sockeye salmon at Lower Granite Dam and transport them to their hatchery facility in Eagle, Idaho. During this emergency trapping operation 770 summer-run Chinook salmon from the Snake River ESU were handled at Lower Granite Dam. There were no reported injuries or mortalities (Ogden 2018).

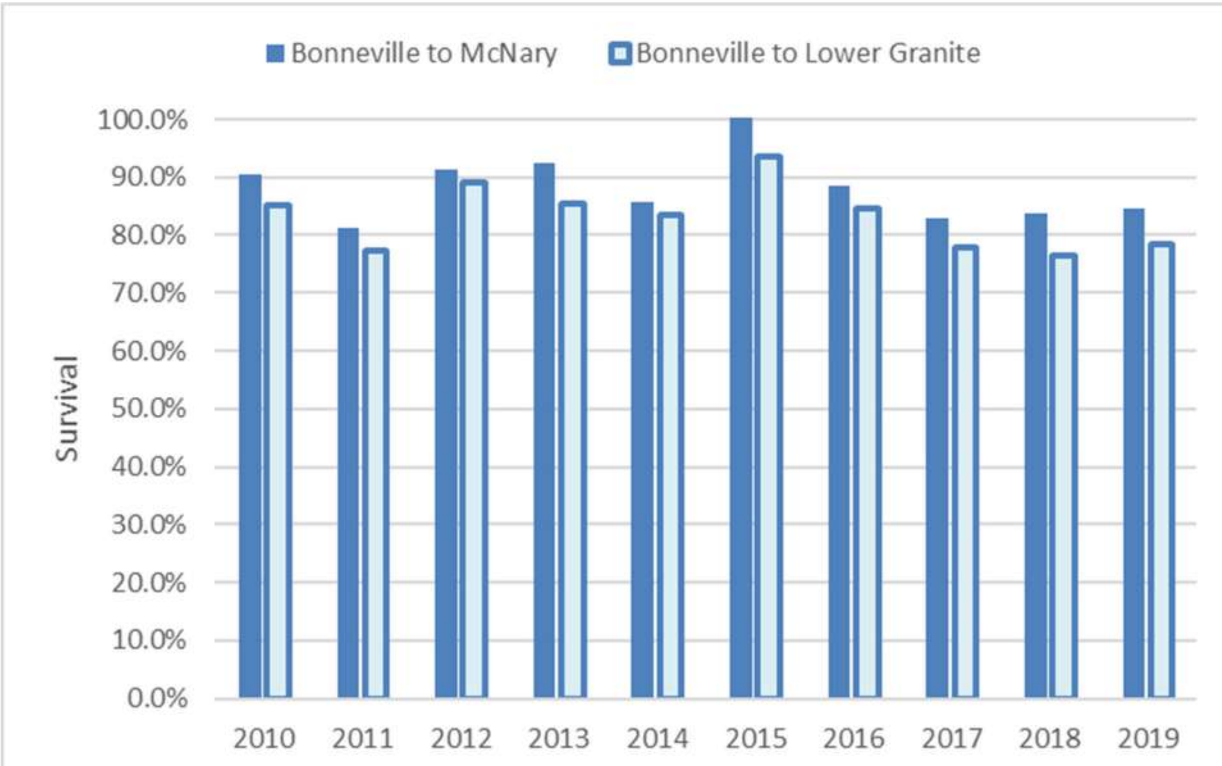

Figure 2.2-6. Minimum survival estimates (corrected for harvest and straying) from Bonneville to McNary and Bonneville to Lower Granite Dams (2010 to 2019) estimated using known-origin PIT-tagged adult SR spring/summer Chinook salmon—natural- and hatchery-origin combined—that migrated inriver as juveniles. Source: Bellerud (2020).

2.2.2.1.6 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and non-native species that are predators, competitors, or food sources for migrating juvenile Chinook salmon. Travel times of migrating smolts increase as they pass through the reservoirs (compared to a free-flowing river), increasing exposure to both native and nonnative predators (see predation section below). Some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spillbays, or surface passage routes) (NMFS 2008a).

However, overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1992, when the species was listed. This is most likely the result of improved structures and operations and predator-management programs at the

Corps' mainstem projects (24-hour volitional spill, surface passage routes, improved juvenile bypass systems, predator-management measures, etc.) (NMFS 2017a).

Table 2.2-7 depicts the Fish Operations Plan (FOP) for spring spill during 2017 through 2020. There was a substantial increase in spill over the dam spillways in the spring during 2018 in response to a court order requiring additional spill. Spill levels in 2019 and 2020, using flexible spill as defined in the proposed action subject to consultation in the 2019 biological opinion, were also higher than spill in 2017. Spring spill, as a percentage of flow at Snake River dams, averaged 37.2 percent, with daily mean spill percentages above the long-term spill average (1993 to 2019) for nearly the entire spring migration period in 2018. In the spring of 2019, during the 120 percent flexible spring spill operation, mean discharge in the Snake River was high, at 45.5 kcfs, which was above the 2006 to 2019 mean of 34.3 kcfs. In 2019, spill averaged 38.5 percent at the Snake River dams, which was above the long-term mean of 34.6 percent, but lower than what would be expected with flexible spill during low and moderate flow years.

Table 2.2-7. Summary of 2017, 2018, 2019, and 2020 Fish Operations Plan spring spill levels at lower Snake River and Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flexible Spill	2020 Flexible Spill
Lower Granite	20 kcfs/20 kcfs	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 20 kcfs Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 20 kcfs Performance Standard (8 hours per day)
Little Goose	30%/30%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)
Lower Monumental	Gas Cap/Gas Cap (approximate Gas Cap range: 20–29 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (uniform spill pattern, 16 hours per day) / 30 kcfs Performance Standard (bulk spill pattern, 8 hours per day)	125% TDG gas cap (uniform spill pattern, 16 hours per day) / 30 kcfs Performance Standard (bulk spill pattern, 8 hours per day)
Ice Harbor	**April 3-April 28:** 45 kcfs/Gas Cap **April 28-June 20:** 30%/30% vs. 45 kcfs/Gas Cap (approximate Gas Cap range: 75–95 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flexible Spill	2020 Flexible Spill
John Day	**April 10–April 28:** 30%/30% **April 28–June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 40% Performance Standard (8 hours per day)	40%/40%
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)	120% TDG gas cap (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)	125% TDG gas cap up to 150 kcfs (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)

[1] Spill operations are described as percent of project outflow or kcfs.

Widener et al. (2018) estimated that juvenile SR spring/summer Chinook salmon survival rates (natural-origin and hatchery combined) from Lower Granite to McNary Dams (four reservoirs and dams) averaged 76.2 percent (ranging from 69.4 to 79.0 percent) from 2008 to 2017, and survival rates from Lower Granite to Bonneville Dams (seven reservoirs and dams) averaged 53.3 percent (ranging from 43.7 to 64.3 percent) for the same time period (Figure 2.2-7). These survival rates incorporate multiple sources of mortality such as passage mortality, natural mortality, and predation.

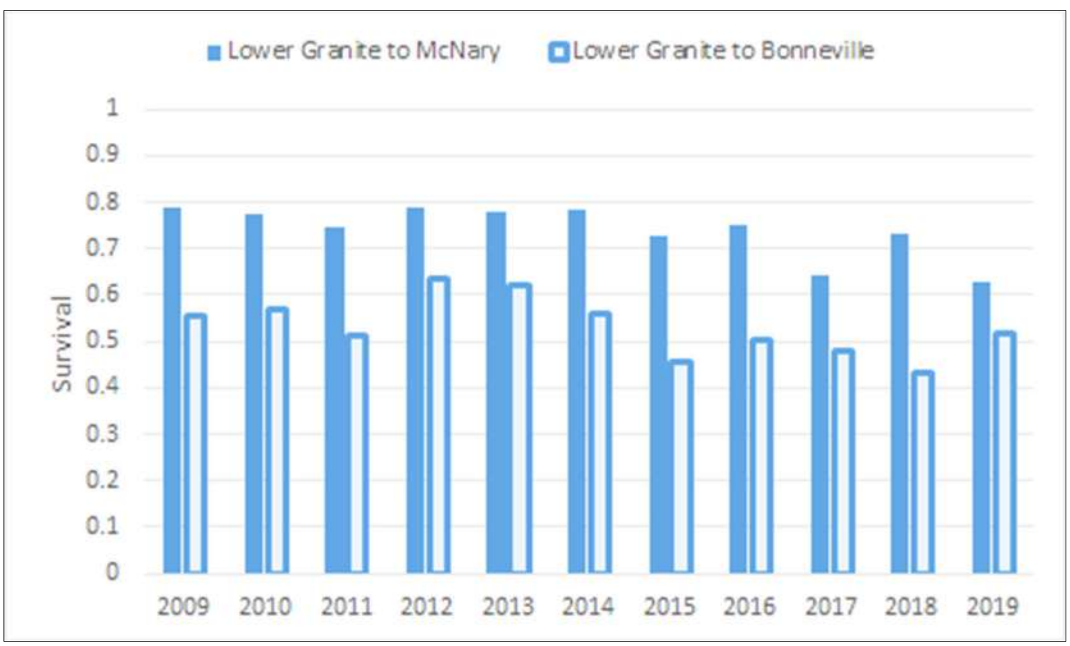

Figure 2.2-7. Survival estimates of SR spring/summer Chinook salmon smolts (natural-origin and hatchery combined) from Lower Granite to McNary and Lower Granite to Bonneville Dams (2008 to 2019). Source: Zabel 2019, Widener et al. 2020.

Based on PIT tag detections, the Lower Granite to Bonneville Dam survival estimate for 2018 during the court-ordered gas cap of 115/120 percent spill was 43.2 percent, which is considerably lower than the long-term average (Widener et al. 2018). However, in 2018, using acoustic tags to estimate juvenile survival rates, Harnish et al. (2019) reported that 55.5 percent of juvenile Chinook salmon survived from Lower Granite to Bonneville Dams, which is slightly higher than the long-term average PIT survival estimate. This information is being used to update and improve the PIT tag survival model. In 2019, during the 120 percent flexible spill operation, Zabel (2019) and Widener et al. (2020) estimated juvenile SR spring/summer Chinook salmon survival from Lower Granite to Bonneville Dam at 52.6 percent using PIT tags, which is similar to the long-term average (arithmetic mean).

Transportation rates in 2018 exceeded 40 percent and were the highest observed since 2008, in contrast to recent trends of decreasing transportation rates. This high transport rate might seem unexpected given the higher spill percentage; it likely resulted from a combination of high river flow and an earlier transport start date of April 23,[44] together with an earlier peak in smolt migration timing. In 2019, flows and spill were again above average and transport started a week earlier than previous years resulting in a relatively high 41.6 and 33.6 percent of natural-origin and hatchery Chinook smolts transported respectively (Zabel 2019, Widener et al. 2020).

Since the implementation of 24-hour spill in 2006, and the installation of surface passage routes at all dams, travel times have decreased substantially for juvenile SR spring/summer Chinook salmon. Consistent with this trend, the higher river flow and spill levels in 2018 and 2019 resulted in travel times that were shorter than the mean travel time (measured in 1997 to 2018) from Lower Granite to Bonneville Dam. Harnish et al. (2019) estimated that juvenile Chinook salmon took 9.7 days to migrate from Lower Granite to Bonneville Dams in 2018. More rapid migration through the CRS can result in less energy expenditure and earlier ocean entry, potentially leading to increased adult returns.

Together, these survival rates, which include effects of hydrosystem operations, represent a substantial improvement in migration conditions and survival rates for juvenile SR spring/summer Chinook salmon migrating through the impounded reaches of the lower Snake and lower Columbia Rivers compared to the 1980s and 1990s (NMFS 2008a), which has the potential to increase the overall productivity of the populations and the abundance of returning adults.

2.2.2.1.7 Transportation

Juvenile fish transport has been used for mitigation in the CRS since 1981 (Baxter et al. 1996). The goal of transportation is to avoid mortality directly caused by migration past dams and thus to increase the number of fish that return as adults. Turbine intake screens, part of the juvenile

[44] From 2008 to 2017, the transport start date was May 1.

bypass systems,[45] divert smolts away from turbine units and into a system of channels and flumes before bypassing them into the tailrace below the dam or collecting them in raceways where they can be loaded onto barges or trucks, transported below Bonneville Dam, and then released into the lower Columbia River to continue migrating to the ocean. Dams currently used for collection are Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam. Yearling Chinook salmon smolts were transported from McNary Dam through 2012, after which all transport from McNary Dam ceased based on a recommendation from NMFS.

The effectiveness of the transportation program is evaluated annually. After the initiation of transportation, nearly all collected fish from the run-at-large are transported. However, the detection and collection system allows for a portion of PIT-tagged fish to continue to be bypassed. This allows assessment of transportation by comparing survival rates of transported and bypassed fish.

The primary metrics for assessing transport apply ratios of smolt-to-adult return (SAR) rates for transported fish relative to SARs for fish that remained inriver and passed through the hydrosystem by other routes during migration. Several types of ratios are useful, differing by which inriver fish are included in the ratio. This document uses two types of transport ratio to describe effects of transport on adult returns. These ratios are described below:

1. Transport-In-River Ratio (TIR): The TIR is the ratio of the SAR of fish transported from Lower Granite, Little Goose, or Lower Monumental Dams, relative to the SAR of fish that never entered a collection system at these dams. PIT-tagged fish used for TIR estimates come only from fish tagged upstream of Lower Granite Dam, and estimates of smolt abundance are adjusted to account for mortality between Lower Granite Dam and the downstream transport site. The Comparative Survival Study (CSS) uses this metric to report transport results.

2. Transport-Bypass Ratio (T:B): The T:B is the ratio of the SAR of fish transported from a specific collector project, relative to the SAR of fish that entered the same collection system and were then bypassed to the river downstream. The NWFSC generally uses this metric to report transport results.

Both of these ratios are used to describe adult return rates to Lower Granite Dam and sometimes to other projects (e.g., Bonneville Dam).T:B and TIR greater than one indicate that transported fish returned as adults to Lower Granite Dam at higher rates than corresponding bypassed or inriver fish. T:B and TIR less than one indicate that transported fish returned as adults at lower rates than corresponding bypassed or inriver fish. Because the two ratios compare effects of transportation to effects of different passage routes, they can address different management questions. The T:B provides direct evidence regarding the alternative management options for fish that enter the juvenile bypass system at a collector dam. A T:B greater than one indicates

[45] Almost all powerhouses at the eight CRS mainstem dams have juvenile bypass systems. The exceptions are The Dalles Dam and Powerhouse 1 at Bonneville Dam.

that, among the subset of fish that entered the powerhouse and were diverted into the bypass system, transported fish had higher SARs than bypassed fish. The TIR provides a different perspective, by comparing SARs for transported fish to those for fish that never entered a bypass system at a Snake River collector project. These inriver fish passed all collector dams via spillways or turbines. A TIR less than one suggests that management options should focus on decreasing the total number of fish entering the powerhouse.

Estimates from PIT-tagged fish have shown that fish that are bypassed at one or more collector dams generally have lower SARs than inriver fish that pass without ever encountering a bypass system. The majority of these never-detected fish pass dams via spillways, with a minority passing via turbines. For SR spring/summer Chinook salmon, T:B estimates tend to exceed TIR estimates. In this sense, TIR represents a higher standard by which to assess the efficacy of transportation. Both measures have merits and are best viewed collectively. An advantage of T:B is that data on transport effects can be evaluated on a finer temporal scale than is possible with TIR. Each PIT-tagged fish that enters the bypass system is detected. Thus, the date on which the fish was transported or bypassed is known, and date-specific T:Bs can be estimated. Fish that pass through spillway or turbine routes are not detected, and thus have an unknown passage date, which means that TIR can be estimated only on an annual scale.[46]

Juvenile SR spring/summer Chinook salmon begin arriving at the three collector dams in early- to mid-April. Since 2006, fisheries managers have chosen not to transport fish in the run-at-large for the first three or four weeks of April; fish that enter the juvenile bypass system are exclusively bypassed during this early period. This choice was based on temporal T:B data from prior years that showed no benefit for fish transported early in the season. The same data set showed that later in the season, starting in late April or early May, transportation resulted in higher SARs than bypassing. Thus, since 2006 managers generally have chosen to initiate transportation around May 1st. For the years 2018 and 2019, the fishery managers chose to start transport on April 24. The earlier date was selected because in recent years juveniles had begun migrating earlier and the majority of the run would often pass the projects before transport was started on May 1.[47] The earlier start date also allows an evaluation of transport during the last week of April, which will provide managers information to assess transport decisions in this timeframe.

Annual T:B estimates are derived from data collected only during the "transportation period;" fish that were bypassed in April before transportation are excluded from the calculation. Because the inriver fish used in calculating TIR do not acquire a "date stamp" when they pass the

[46] A PIT-tag detection system has been installed in one spillbay at Lower Granite Dam, and will be used for the first time in smolt migration year 2020. This will be the first time that a passage route other than a juvenile bypass system has been monitored.

[47] On average (2010-2019) for SR spring/summer Chinook salmon, the proportion of the total annual smolt outmigration that had arrived at Lower Granite Dam was 10 percent on April 15, and 50 percent on May 2 (DART 2020j).

collector dams, the annual TIR estimates include the fish that were bypassed during the early period, when there were no corresponding transported fish.

In recent smolt migration years (2007 to 2019), the average percentage transported was 32.1 percent (range 11.4 to 54.3) for natural-origin and 30.9 percent (range 13.6 to 45.3) for hatchery SR spring/summer Chinook salmon. These estimates represent a substantial reduction from the period from 1993 to 2006, when proportions transported averaged 80.9 percent for natural-origin and 76.7 percent for hatchery SR spring/summer Chinook salmon (Widener et al. 2020). The reduction in recent years was due to both increased spill levels and a later transport start date (typically around May 1) at the three Snake River collector projects. Transport rates for SR spring/summer Chinook salmon smolts in 2018 and 2019 were higher than for most recent years, however, due to relatively early start dates (April 23 in 2018 and April 24 in 2019). In 2018, 44.1 percent of natural-origin and 45.4 percent of hatchery smolts were transported. In 2019, 41.6 percent of natural-origin and 33.6 percent of hatchery smolts were transported (Widener et al. 2020).

In most cases, for hatchery and natural-origin SR spring/summer Chinook from smolt migration years 2006-2017, SARs were higher for transported fish than for bypassed or inriver fish, i.e., the T:B or TIR were greater than 1.0 (Table 2.2-8; Smith et al. 2018, CSS 2019). The year 2006 was chosen as the earliest year for this analysis, because 2006 was the first year that spill was provided on a 24-hour basis at all Snake River projects, and also the first year that transportation began mid-season, and these strategies are likely to continue in some form into the future.

Table 2.2-8. Analysis of effects of transport on adult return rates for hatchery (aggregate) and natural-origin SR spring/summer Chinook salmon using the NWFSC metric, T:B (Smith et al. 2018) and the CSS metric, TIR (CSS 2019).

	T:B (NWFSC metric)		**TIR[1] (CSS Metric)**	
Year	**Hatchery Chinook Salmon**	**Natural-origin Chinook Salmon**	**Hatchery Chinook Salmon (range)**	**Natural-origin Chinook Salmon**
2006	1.66	1.20	0.48 - 2.1	0.79
2007	2.90	1.87	1.35 - 2.1	1.28
2008	1.55	1.67	0.91 - 4.17	1.19
2009	1.71	1.29 - 1.98	1.29 - 1.98	1.11
2010	1.21	1.25	0.7 - 1.52	1.22
2011	0.91	0.86	0.33 - 1.92	0.69
2012	1.42	1.56	0.83 - 1.36	0.72
2013	1.58	1.44	0.63 - 1.62	1.43
2014	2.92	4.63	1.18 - 3.3	2.05
2015	3.98	34.39	0.77 - 6.44	4.28
2016	3.42	2.57	1.03 - 2.35	2.43
2017[2]	1.01	1.79	0.4 - 1.95	1.18
Geometric mean	1.81	2.19	--	1.32

NOTE: NMFS T:B estimates represent a comparison of SARs for fish tagged above Lower Granite Dam and either transported (T) or bypassed (B) at Lower Granite Dam. The CSS TIR estimates come from the 2019 CSS Annual Report, and represent the T_0 or T_x SAR, relative to fish never detected at a collector project (C_0 SAR).

[1]For SR spring/summer Chinook salmon, TIR is reported as the range in estimates for ESA-listed Snake River hatchery programs, and the estimated TIR for natural-origin fish

[2] Incomplete adult returns at time of analysis.

The efficacy of smolt transportation as a mitigation measure varies by species, rearing type, and collector dam. Transportation has generally benefited hatchery and natural-origin SR spring/summer Chinook salmon. Results for fish transported from Little Goose Dam are generally similar to those transported from Lower Granite Dam. However, transportation is generally less beneficial from Lower Monumental Dam, where fewer fish are transported than from the dams farther upstream.

While the overall result is positive, smolt transportation is not a panacea (Williams et al. 2005). Informally, a regional goal is for survival of inriver migrants to meet or exceed that observed for transported fish. That goal has not yet been met for spring migrants, but survival rates for transported fish provide an important benchmark. The alternative to transportation is to improve inriver migration conditions to the point where transportation provides little benefit. Over the last several decades various transportation strategies have been proposed and have been reviewed by the ISAB, most recently in 2010 (ISAB 2010). The guidance provided by the ISAB has been consistent, which is to “spread the risk” between transport and inriver passage, and to measure the effects of inriver survival and transportation over time. The T:B and TIR ratios provide the information necessary to measure these effects.

Since 2006, efforts to improve conditions for smolts migrating inriver have included the provision of 24-hour spill during juvenile migration at all of the mainstem projects, the addition of surface passage structures, and the relocation of juvenile bypass outfall locations to improve inriver survival of bypassed fish. The most recent change was the implementation of the Flexible Spill Agreement, which as of spring 2020 had increased spring spill levels up to a 125 percent TDG tailrace standard (16 hours per day) at the Snake River projects and McNary Dam (NMFS 2019a).

While higher spill is anticipated to result in fewer smolts at a project being bypassed and collected for transport, that effect is not uniform under all flow conditions. At a given spill level, more fish will pass via spill under low-flow conditions. In the low-flow year 2015, only 12.5 percent of spring Chinook salmon smolts that arrived at Lower Granite Dam were ultimately transported from one of the collector dams (Zabel 2019, Widener et al. 2020). Migration year 2015 also had below-average inriver survival (45.7 percent smolt survival between Lower Granite and Bonneville Dams), and transport provided an above-average survival advantage for hatchery spring Chinook salmon (TIR of 2.87 and T:B of 4.0 from Lower Granite Dam) and natural-origin spring Chinook salmon (TIR of 3.8 and T:B of 34.4 from Lower Granite Dam). Thus, when inriver conditions are poor due to low flows and high water temperatures, as in 2015, in-season management decisions must weigh the potentially large benefits of increasing the proportion of fish transported against the general desire to improve inriver conditions, with spill as the main strategy identified to date.

In general, determining an “optimum” transport operation is challenging for several reasons. The benefit of transportation varies seasonally, by river flow and temperature conditions, by collector dam, and likely also because of differing ocean conditions at the time of ocean entry for transported and inriver migrants. Seasonal patterns in the SARS of transported and inriver migrants also vary by species and rearing type. Broadly speaking, juvenile transport continues to show an overall benefit for SR spring/summer Chinook salmon, in the form of rates of survival to adulthood that exceed those for fish that are not transported. However, the degree of benefit has decreased since 2006, when management modifications (increased spill and initiation of smolt collection later in the migration season) were implemented. Subsequently, inriver survival has increased and the proportion of smolts being transported has decreased.

In addition, transport has unintended consequences. Handling and transport of juveniles results in their being held at much higher densities than observed in the wild, increasing the risk of disease transmission. Also, because it takes inriver migrating fish several weeks to travel from the lower Snake River to Bonneville Dam, and they are growing during that period, inriver migrants are larger and enter the Columbia River estuary and plume later in time than transported fish. Smaller size at ocean entry is associated with reduced survival (NMFS 2014a). These factors, in some combination, likely contribute to the sometimes observed higher mortality for transported fish after being released from barges compared to inriver migrating smolts as evidenced by adult returns to Bonneville Dam (NMFS 2008a).

Another unintended consequence of transportation is increased straying of returning adults (Keefer and Caudill 2014). Smolts that migrate inriver generally take 1 to 3 weeks to travel from Lower Granite Dam to Bonneville Dam (Widener et al. 2020), imprinting on the varying water chemistry of tributaries as they go. Smolts transported in barges follow the course of the river, but they make the trip in 2 to 3 days. It appears that the reduced transit time can impair the acquisition of waypoints along the migration route and this can result in less directed upstream migration for adults. PIT tag data indicate that SR spring/summer Chinook that were transported as juveniles generally have longer travel times and higher fallback reascension rates compared to fish that migrated in-river as juveniles. Adult straying associated with juvenile transport is more commonly observed in steelhead, however, than in Chinook salmon. Marsh et al. (2015) found that for SRB steelhead transported as juveniles in 2006 to 2008, 6.7 to 9.5 percent strayed as adults during their upstream migration, with 5 to 7 percent of the adult migrants permanently lost (i.e., never detected at Lower Granite Dam as adults). In contrast, for SR spring/summer Chinook transported as juveniles in these same years, only 0.3 to 3.2 percent strayed as adults (all were permanently lost).

The SARs presented in this document are based on adults counted at Lower Granite Dam. Thus, losses of transported fish resulting from straying are accounted for, and TIR and T:B estimates still show a general benefit of transport. Uncertainty remains about whether alteration of adult-homing behavior has important consequences for fitness after adults successfully pass Lower Granite Dam. In addition, Snake River fish that permanently stray into and spawn in non-natal streams can have an adverse effect on the native population of those streams (Keefer et al. 2008, Keefer and Caudill 2014).

2.2.2.2 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Currently, there are currently 18 spring/summer Chinook salmon hatchery programs in the Snake River basin. Most of these programs are integrated with the natural populations and release hatchery fish into rivers with ESA-listed natural-origin SR spring/summer Chinook salmon. Snake River spring/summer Chinook salmon hatchery program production levels have remained stable since the most recent status review (NMFS 2016b). Many captive broodstock programs initiated during the 1990s to conserve SR spring/summer Chinook salmon genetic resources were terminated after the status of these fish improved.

Over the years, hatchery programs that supplement natural-origin populations in the Snake River have made improvements to their hatchery programs. In particular, program managers have better integrated natural-origin fish into their broodstock. Integration of hatchery programs is typically done using sliding scales sensitive to population abundance. Under the sliding scales, the programs allow some hatchery-origin fish to spawn in the wild at all abundance levels, but reduce the proportions of hatchery-origin spawners as natural-origin abundance increases. In addition the proportion of natural-origin fish used in broodstock increases as abundance increases, as determined by the sliding scales. This strategy attempts to balance the risk of extinction (low natural-origin abundance) with the risk of hatchery influence.

Similarly, hatchery programs that are segregated from the natural-origin population have made improvements in release and collection strategies to reduce straying. This reduction in straying has reduced the potential for these segregated programs to impact naturally spawning Chinook salmon.

The following subsections provide additional information on hatchery programs by location.

2.2.2.2.1 Clearwater River

Four hatchery programs operate in the Clearwater River basin. Chinook salmon in the Clearwater River are not part of the listed SR spring/summer Chinook salmon ESU, and critical habitat for the ESU was not designated in the Clearwater River basin. The hatcheries in the Clearwater basin are operated as segregated programs, and focus on keeping hatchery fish separate from natural-origin populations. NMFS completed a consultation on these programs in 2017 and determined that the programs are not likely to appreciably reduce the likelihood of survival and recovery of the SR spring/summer Chinook salmon ESU (NMFS 2017b). These hatchery programs have implemented new strategies to limit straying of program fish into areas where ESA-listed fish are present (NMFS 2017b). The hatchery programs operating in the Clearwater River include:

- Kooskia spring Chinook.
- Clearwater Fish Hatchery spring/summer Chinook.
- Nez Perce Tribal Hatchery spring/summer Chinook.
- Dworshak spring Chinook.

2.2.2.2.2 South Fork Salmon River

There are five hatchery programs operating in the South Fork Salmon River basin: three integrated programs and two segregated programs. NMFS completed a consultation on these programs 2019 (NMFS 2019b). The hatchery programs are:

- South Fork Salmon River summer Chinook.
- South Fork Chinook Egg Box Project summer Chinook.
- Johnson Creek Artificial Propagation and Enhancement Project summer Chinook.
- Rapid River spring Chinook.
- Hells Canyon spring Chinook.

The South Fork Salmon River summer Chinook salmon hatchery program, operated by the McCall Fish Hatchery, has two components (segregated and integrated), with a recently implemented genetic relationship between them. A sliding scale is used to manage the level of integration between the hatchery and natural populations for the integrated component, and a percentage of returning fish from the integrated component will be used as broodstock in the segregated component. This type of genetic linkage is sometimes referred to as a “stepping stone” system (HSRG 2014). Initial analysis by NMFS shows that these linked programs pose considerably less risk of hatchery-influenced selection than solely segregated programs, because they maintain a genetic linkage with the naturally spawning population (Busack 2015). In this case, the presence of returning segregated hatchery-origin adults on the South Fork Salmon River spawning grounds poses little additional risk compared to integrated hatchery-origin adults.

The South Fork Salmon River summer Chinook salmon hatchery program also contributes eyed-eggs to the South Fork Chinook salmon egg box program,[48] meaning that segregated hatchery fish produced in the egg box program are also genetically linked to a naturally spawning

[48] Eyed eggs are fertilized salmon eggs that have developed to the stage where a black dot representing the eye and the early nervous system is easily visible. These eggs are less sensitive to movement and can be handled safely (e.g., for transportation).

population. As noted above, genetically linked programs are considered to pose less risk of hatchery-influenced selection than segregated programs (Busack 2015).[49]

The Johnson Creek Artificial Propagation Enhancement (East Fork, South Fork Salmon River) program has always used 100 percent natural-origin fish in its broodstock, so it maintains a strong link to the natural-origin population.

The Rapid River (Little Salmon/South Fork Salmon River) and Hells Canyon programs (Upper Snake River) are segregated programs that produce fish for harvest purposes. As described in the most recent biological opinion, these programs have developed new strategies to limit straying and ecological interactions between hatchery and ESA-listed natural-origin fish (NMFS 2019b).

NMFS completed a consultation on these programs in 2019 and determined that the programs are not likely to appreciably reduce the likelihood of survival and recovery of the SR spring/summer Chinook salmon ESU (NMFS 2019b).

2.2.2.2.3 Upper Salmon River

There are four hatchery programs in the upper Salmon River basin, all of which are integrated with the natural-origin populations. The programs are:

- Upper Salmon River spring Chinook (Sawtooth).
- Yankee Fork spring Chinook.
- Pahsimeroi summer Chinook.
- Panther Creek summer Chinook.

The Upper Salmon River spring Chinook (Sawtooth) hatchery program operates similarly to the South Fork Salmon River program described above, with both an integrated and a segregated component. A sliding scale is used to manage the level of integration between the hatchery and natural populations for the integrated component, and a percentage of returning fish from the integrated component will be used as broodstock in the segregated component.

The Yankee Fork program is related to the Sawtooth program, as broodstock from the Sawtooth program are being used to jump start the Yankee Fork program. Over time, broodstock will be collected solely in Yankee Fork, and a sliding scale will be used to manage the level of integration between the hatchery and natural populations.

Like the Sawtooth Program, the Pahsimeroi program has both an integrated and segregated component. A sliding scale is used to manage the level of integration between the hatchery and

[49] The South Fork Chinook salmon egg box program was previously operated under the name "Dollar Creek Egg Box Program."

natural populations for the integrated component, and a percentage of returning fish from the integrated component will be used as broodstock in the segregated component.

The Panther Creek program is related to the Pahsimeroi program, as broodstock from the Pahsimeroi program are being used to jump start the Panther Creek program. Over time, broodstock will be collected solely in Panther Creek, and a sliding scale will be used to manage the level of integration between the hatchery and natural populations.

NMFS completed a consultation on these programs in 2017 and determined that the programs are not likely to appreciably reduce the likelihood of survival and recovery of the SR spring/summer Chinook salmon ESU (NMFS 2017c).

2.2.2.2.4 Grande Ronde/Imnaha Rivers and Lower Snake River

Six hatchery programs operate in the Grande Ronde/Imnaha and lower Snake River basins. All six programs are integrated with, and intended to supplement, natural-origin populations. Sliding scales are used to manage the level of integration between the hatchery and natural populations for the integrated component. NMFS completed a consultation on these programs in 2016 and determined that the programs are not likely to appreciably reduce the likelihood of survival and recovery of the SR spring/summer Chinook salmon ESU (NMFS 2016c). The programs are:

- Catherine Creek spring/summer Chinook.
- Lookingglass Creek spring Chinook.
- Lostine spring/summer Chinook.
- Upper Grande Ronde spring/summer Chinook.
- Imnaha River spring/summer Chinook.
- Tucannon River Endemic spring Chinook.

2.2.2.3 Recent Ocean and Lower River Harvest

SR spring/summer Chinook salmon are exposed to fisheries in the Columbia River estuary, mainstem Columbia River, Snake River, and, to varying degrees, the ocean and Snake River tributaries. The ocean fishery mortality impact on upriver spring/summer Chinook salmon is very low and, for practical purposes, assumed to be zero, based on the rare occurrence of coded-wire tag (CWT) recoveries in ocean fisheries (PFMC 2019). We believe that the migration path and ocean distribution of SR spring/summer Chinook salmon are such that they are not present in nearshore areas where ocean salmon fisheries traditionally occur (NMFS 2014b). A recent examination of Chinook salmon stock ocean distribution using CWT data from 2006 to 2016 provides further evidence that SR spring/summer Chinook salmon still experience exploitation rates less than 1 percent across all marine fisheries combined (PFMC 2019).

Fisheries are currently managed to focus on different stocks and populations to meet commercial, recreational, and tribal needs. Fisheries influence salmonid population viability by causing direct and incidental mortality in natural-origin fish (NMFS 2018a). Information made available since the last ESA status review indicates that harvest impacts remain relatively constant for SR spring/summer Chinook salmon (TAC 2017).

Fisheries in the Columbia River basin, particularly in the mainstem of the Columbia River, are managed pursuant to fishing plans developed by the parties to *U.S. v. Oregon* Management Agreement. Parties to this process include the Federal government; the states of Oregon, Washington, and Idaho; and the four Columbia River Treaty Tribes and the Shoshone-Bannock Tribes. Incidental take of ESA-listed SR spring/summer and UCR spring Chinook salmon occurs in spring- and summer-season fisheries in the mainstem Columbia River that target harvestable hatchery and natural-origin stocks (NMFS 2014b). Allowable harvest depends on the total (hatchery + natural-origin) abundance of upriver spring Chinook salmon. The aggregate upriver spring Chinook salmon run includes, and may be limited by, either natural-origin SR spring/summer Chinook salmon or natural-origin UCR spring-run Chinook salmon. Under these rules, the allowable harvest rate (on natural-origin fish), including treaty and non-treaty Columbia River fisheries combined, may range from 7 to 14.6 percent of the predicted Columbia River return per year (NMFS 2018a). The average annual harvest rate of these fish from 2008 to 2017 under the jurisdiction of the *U.S. v. Oregon* Management Agreement averaged 12.1 percent (NMFS 2018a).

Salmon and steelhead fishing also occurs in the Snake River mainstem and its tributaries in the states of Washington, Oregon, and Idaho. Fisheries in the lower Snake River (downstream of the Washington/Idaho border to the confluence with the mainstem Columbia River) during the spring are under the jurisdiction of the *U.S. v. Oregon* Management Agreement and incorporated into the harvest rates reported above. For fisheries operating upstream in Idaho, co-managers currently develop and submit to NMFS yearly Fishery Implementation Plans (FIPs). The FIPs include annual pre-season fishery impact rates consistent with fishery management frameworks developed through the Snake Basin Harvest Forum, an offshoot of the *U.S. v. Oregon* Management Agreement process. These frameworks were developed based on sliding scales that link allowed fishery impact rates to forecasted returns of natural-origin adults (NMFS 2014b). The framework for allowable total mortality is based on whether a spawning population is supplemented with hatchery-origin fish. The sliding scale of allowable total mortality impacts is applied against the expected aggregate adult run size of natural populations as a percentage of the pooled Minimum Abundance Thresholds (MATs) of affected populations (Tables 2.2-9 and 2.2-10). Pooled MATs occur across specific Fishery Management Areas—the Mainstem Snake River, Lower Salmon River, South Fork Salmon River, Upper Salmon River, and Clearwater River. Fisheries are managed within the allowable total mortality framework. The FIPs are implemented in the Snake River basin in the state of Idaho, including the mainstem Snake River and the Salmon and Clearwater subbasins.

Table 2.2-9. Allowable total mortality rate and combined tribal and non-tribal fisheries (shaded) for spring/summer Chinook salmon in populations with returning hatchery-origin adults.

% Minimum Abundance Thresholds (MAT)		**Total Allowable Natural-origin Mortality Rate**
Lower	**Upper**	
	30%	1%
30.1%	50%	4%
50.1%	75%	9%
75.1%	108%	12%
108.1%		42% of margin

Table 2.2-10. Allowable total mortality rate and combined tribal and non-tribal fisheries (shaded) of spring/summer Chinook salmon in unsupplemented populations.

% MAT Sum		**Total Allowable Natural-origin Mortality Rate**
Lower	**Upper**	
	30%	0%
30.1%	50%	3%
50.1%	75%	5%
75.1%	108%	8%
108.1%		35% of margin

Fisheries operating in the Grande Ronde and Inmaha Rivers and tributaries targeting adult spring Chinook salmon are subject to separate FIPs. The first management priority for these fisheries is to achieve natural escapement or hatchery broodstock goals, using the harvest management framework for SR natural-origin adult spring/summer Chinook salmon described in Table 2.2-11. The fisheries are managed according to total population-specific ESA take limits, regardless of which fishery entity kills the fish. Calculations of allowable ESA take, using the information presented in Table 2.2-11, account for both direct (immediate mortality) and indirect effects (delayed mortality) (NMFS 2013e).

Table 2.2-11. General sliding-scale harvest-rate schedule for total and tribal ESA-defined impacts resulting from the implementation of fisheries that target adult spring Chinook salmon runs in Grande Ronde and Imnaha Rivers and tributaries (from NMFS 2013e).

Fishery Scenario	**Expected Return of Natural-Origin Fish**	**Total Collective Natural-Origin Mortality**
A	Below Critical Threshold	1%
B	Critical to MAT	A + 11% of margin above A (8%)
C	MAT to 1.5X MAT	B + 22% of margin above B (16%)
D	1.5X MAT to 2X MAT	C + 25% of margin above C (19%)
E	Greater than 2X MAT	D + 40% of margin above D (28%)

2.2.2.4 Tributary Habitat

2.2.2.4.1 ESU Overview

Tributary habitat conditions for SR spring/summer Chinook salmon vary significantly throughout the Snake River basin: in some areas, spawning and rearing habitat is in near-pristine condition, while in others it is minimally to highly degraded as a result of past or present human activities. Generally, the ability of tributary habitats in the Snake River basin to support the viability of this ESU is limited by one or more of the following factors: 1) impaired fish passage, 2) reduced stream complexity and channel structure, 3) excess fine sediment, 4) elevated summer water temperature, 5) diminished stream flow during critical periods, 6) reduced floodplain connectivity and function, and 7) degraded riparian condition. The combination, intensity, and relative impact of these factors vary locally throughout the basin, depending on historical and current land use activities and natural conditions (NMFS 2017a).

Human activities that have contributed to these limiting factors include grazing, mining, timber harvest, agricultural practices, road construction, water withdrawals, urban development, and recreational use (NMFS 2017a). Natural disturbances, particularly fire, have also had an impact recently in several subbasins. Fires are natural disturbances that, from an ecological perspective, allow over time for the development and maintenance of the complex habitats needed by salmonids. However, in the near term, they are also likely to result in higher runoff rates and erosion, leading to increased sediment load and streambed scouring, with associated adverse effects on salmon productivity (Bixby et al. 2015, Flitcroft et al. 2016). Changes in precipitation and temperature also have influenced, or are likely to influence, trends in habitat conditions. Changes are predicted to include more precipitation falling as rain rather than snow; diminished snowpack and altered stream flow, volume, and timing; lower late summer flows; higher summer and fall water temperatures; and increased impacts of drought due to more dry and warm years (NMFS 2017a).

In general, land use practices and regulatory mechanisms have improved from past practices and regulations (NMFS 2017a). Roper et al. (2019), for instance, reviewed the status and trends of 10 stream habitat attributes to evaluate whether changes in Federal land management had altered the trajectory of stream habitat conditions in the interior Columbia River basin. They concluded that changes in management standards and guidelines made in the 1990s are related to improved stream conditions, although they were not able to determine the precise magnitude of the changes. However, ongoing development and land-use activities are likely to continue to have some negative effects (NMFS 2016b).

Many tributary habitat improvement actions have been implemented throughout the Snake River basin through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies (BPA et al. 2013, 2016, 2020; NMFS 2016b, 2017a; BOR 2018, 2019b). The Action Agencies have been implementing tributary habitat improvement actions as part of mitigation for the CRS since 2007. These actions have been targeted toward addressing the limiting factors identified above, and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat (BPA et al. 2013, 2016, 2020). Cumulative metrics for these action types for SR spring/summer Chinook salmon from the years 2007 to 2019 are shown in Table 2.2-12.

Table 2.2-12. Tributary habitat improvement metrics: SR spring/summer Chinook salmon, 2007 to 2019 (BPA et al. 2020, McLaughlin 2020).

Action Type*	Amount completed
Acre-feet/year of water protected (by efficiency improvements and water purchase/lease projects)	91,245
Riparian acres protected (by land purchases or conservation easements)	3,286
Riparian acres improved (to improve riparian habitat, such as planting native vegetation or control of noxious weeds)	7,110
Miles of enhanced or newly accessible habitat (by providing passage or removing barriers)	1,341
Miles of improved stream complexity (by adding wood or boulder structures or reconnecting existing habitat, such as side channels)	204
Miles protected (by land purchases or conservation easements)	188
Screens installed or addressed (for compliance with criteria or by elimination/consolidation of diversions)	90

*Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediment and reconnecting floodplains.

NMFS has determined, based on best available science, that the actions implemented by the Action Agencies and other entities have improved, and will continue to improve, habitat in the targeted populations as these projects mature, and that fish population abundance and productivity will respond positively. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions). Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

RME has been underway for this ESU to evaluate changes in habitat and fish populations as a result of habitat improvement actions. Available empirical evidence supports our view that these actions are improving tributary habitat capacity and productivity, and that fish are responding. Below, we include limited examples of RME results specific to SR spring/summer Chinook salmon, while Appendix A summarizes the scientific foundation for our determination, including relevant RME information from throughout the Columbia River basin and other lines of evidence that we considered regarding the effects of habitat improvement actions. It also discusses the complexities of evaluating the effects of habitat restoration on fish populations (see Appendix A; also see NMFS 2014a, Hillman et al. 2016, ISAB 2018, Griswold and Phillips 2018, Haskell et al. 2019).[50]

For some populations in this ESU, NMFS used life-cycle models to evaluate the effects of tributary habitat improvement actions implemented to date. Results of these evaluations are summarized below, and the models and results are described in more detail elsewhere in this section and in supporting documents (Pess and Jordan, eds. 2019, Zabel and Jordan 2020).

The best available scientific and technical information also indicate that, in most areas, there is additional potential to improve habitat productivity, although in some areas the potential is limited or uncertain (NMFS 2016b, 2017a; Idaho OSC IRA Team 2019, Pess and Jordan, eds. 2019). Strong density dependence has been observed in SR spring/summer Chinook salmon populations (ISAB 2015, Idaho OSC IRA Team 2019), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stages and limiting factors, would likely improve overall population abundance and productivity.[51]

Density dependence in populations spawning above Lower Granite Dam is illustrated in an analysis by the IDFG. The IDFG tracks adult and juvenile spring Chinook salmon passing Lower Granite Dam and estimates abundance, composition, and productivity in the aggregate and by

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[50] The goal of the tributary habitat program is to implement tributary habitat actions that address priority limiting factors and improve population abundance, productivity, spatial structure, and diversity. Measuring the effects of habitat restoration for fish and other aquatic and riparian biota is “one of the great challenges of river and stream conservation” (ISAB 2018). To draw conclusions about the benefits of tributary habitat improvements, we evaluated multiple lines of evidence, including knowledge of the basic relationships between fish and their tributary habitat, findings in the scientific literature about how changes in fish habitat affect fish populations, literature on the physical and biological effectiveness of tributary habitat improvement actions, correlation analyses, results from monitoring in the Columbia River basin designed to evaluate the effects of various actions on tributary habitat limiting factors and on salmon and steelhead population response, and the results of life-cycle models. Those lines of evidence and our conclusions are summarized in Appendix A.

[51] Density dependence occurs when a change in the number of fish in a given area (fish density) causes a change in a fish population's growth rate. Most commonly, the population's growth rate slows as the number of fish increases (typically as a result of competition for limiting resources such as food or habitat) and, in turn, increases as the number of fish decreases.

stock and MPG, using data from biological samples. They estimate freshwater productivity rates through brood-year cohort analysis and juvenile production potential using juvenile-to-female stock recruitment models (Camacho et al. 2019a, 2019b). Their data show density dependence in the relationship of juvenile production to females available for natural reproduction (Figure 2.2-8).

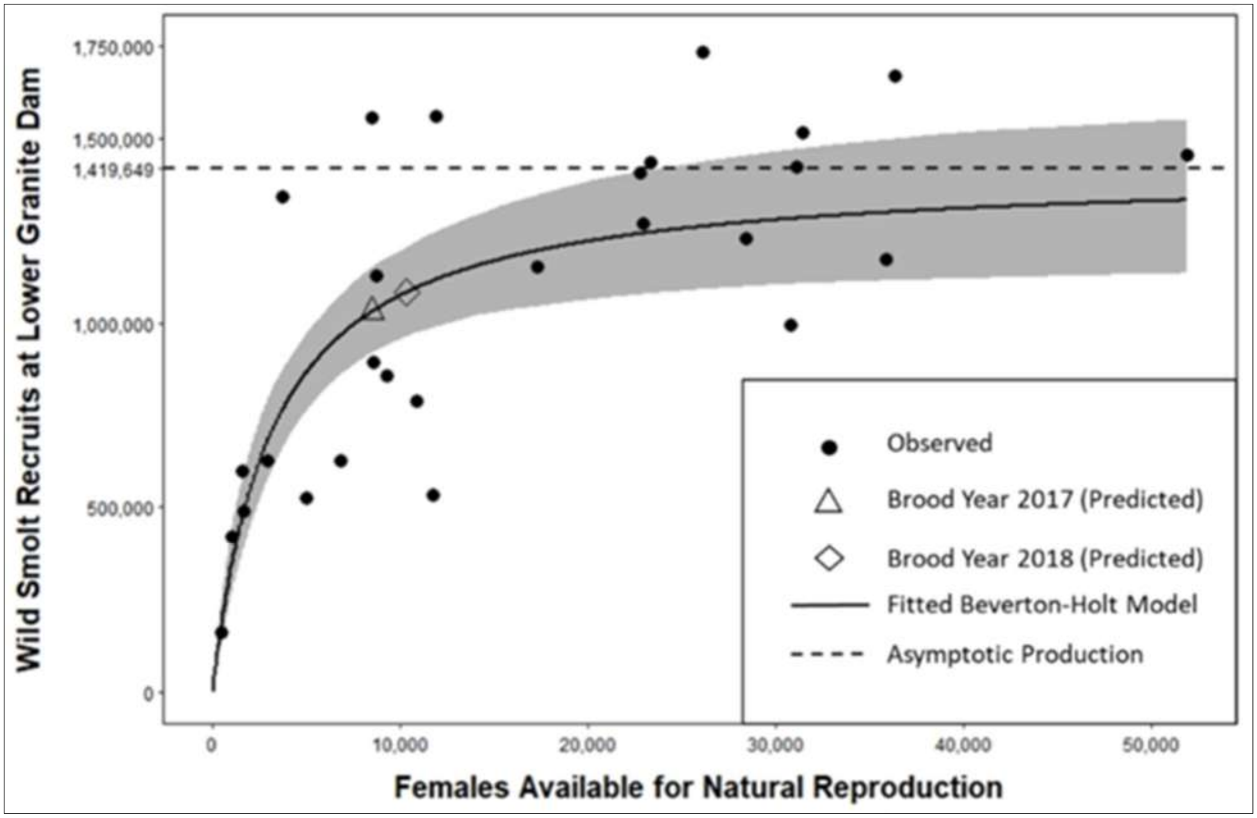

Figure 2.2-8. Comparison of observed natural-origin yearling Chinook salmon juvenile abundance at Lower Granite Dam and females available for natural reproduction upstream of Lower Granite Dam for brood years 1990 to 2016. The Beverton-Holt stock-recruitment model's prediction of juvenile production for brood years 2017 and 2018 was included for comparison. The shaded area represents the 95 percent confidence interval for the fitted Beverton-Holt model (Camacho et al. 2019b).

Figure 2.2-8 shows that there appears to be a fairly substantial limitation on the number of juveniles that the habitat is able to produce upstream of Lower Granite Dam (roughly 1.4 to 1.7 million spring Chinook smolts). Camacho et al. (2019b) note that there are multiple potential explanatory hypotheses for this pattern, including loss of habitat, loss of marine-derived nutrients, habitat fragmentation, high temperatures, competition with hatchery fish, and others. Overall, these data are consistent with ISAB (2015) and support the concept that improvements in tributary habitat capacity or productivity, if targeted at limiting life stages and limiting factors, would likely improve overall population abundance and productivity.

More detail on tributary habitat conditions for the five MPGs (and 28 extant populations) that constitute this ESU is provided below.

2.2.2.4.2 South Fork Salmon River MPG

The South Fork Salmon River MPG historically supported four SR spring/summer Chinook salmon populations: the Little Salmon River, South Fork Salmon River, Secesh River, and East Fork South Fork Salmon River. All of these populations are extant (NMFS 2017a).

The spawning and rearing areas used by these four populations are mostly on Federal land,[52] including areas that provide high-quality, intact habitat. Many other areas, however, including areas of both Federal and private lands, have been degraded to some extent by human activities, primarily road construction, mining, timber harvest, livestock grazing, and recreational use. These land uses have resulted in reduced riparian function and vegetation, decreased recruitment of large wood, accelerated sediment loading, and increased water temperatures above thresholds for salmon in some areas. In addition, passage barriers restrict access to historical spawning and rearing habitat in places (NMFS 2017d).

Habitat for the Secesh River population is generally highly productive, as is habitat for the South Fork Salmon River population, although there are greater legacy impacts in the South Fork Salmon drainage from human land use (especially road networks), and from major wildfires that occurred in the 1990s and in 2007. In 2007, the Cascade Complex Fire burned riparian areas in important spawning and rearing reaches, resulting in increased sediment and reduced shading (leading to warmer water temperatures).[53] Ongoing sediment monitoring in the South Fork Salmon River drainage indicates that while instream sediment levels are generally decreasing (Zurstadt 2015, as cited in NMFS 2016b), they remain a concern, especially considering the importance of spawning habitat in the drainage. In the East Fork, spawning in one branch of the population was extirpated in the 1940s by sediment and pollutants from mining activities, contributing to the population's current low abundance. The potential for future development of large-scale mining in this watershed, along with recreational impacts (e.g., from fording of streams by all-terrain vehicles), also present challenges to achieving functional habitats in this watershed. Many areas occupied by the Little Salmon River population are also degraded from their historical condition (NMFS 2016b, 2017d).

Restoration actions in this MPG have focused primarily on reducing sediment delivery to streams, restoring fish passage, and improving hydrologic function, primarily through road obliteration and decommissioning; culvert removal or replacement to improve passage; channel restoration to restore stream structure; riparian planting or fencing to restore or protect riparian areas; and habitat protection through acquisitions, conservation easements, and other methods (BPA et al. 2013, 2016, 2020; NMFS 2017d). For example:

[52] Ninety-eight percent of the South Fork Salmon River drainage is managed by the U.S. Forest Service, and 70 percent of the Little Salmon River drainage (included in this MPG) is managed by the US Forest Service.

[53] In some areas, vegetation was re-planted or is being reestablished. These areas will take time to fully mature, but there will be interim benefits as banks stabilize and shade increases.

- In the South Fork Salmon River drainage, over 150 miles of road prisms have been fully obliterated since 2009. In addition, improvements to the road system (e.g., adding gravel stabilizing crossings, replacing fords with bridges or culverts, and installing drainage features) have reduced sediment delivery.
- Eleven fish passage barriers in the South Fork Salmon River basin were replaced with crossings allowing aquatic organism passage, restoring access to over 20 miles of habitat.
- In the Little Salmon River drainage, five culvert barriers have been replaced with structures that allow access to about 6 miles of habitat (NMFS 2016b).

These actions have been targeted toward addressing limiting factors, and best available science indicates that they have improved, and will continue to improve, habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. The benefits of some of these actions will continue to accrue over several decades (see Appendix A).

The U.S. Forest Service and the Nez Perce Tribe have been active restoration partners for this MPG. Action Agency efforts for this MPG under the 2008 and 2019 biological opinions were focused on the Secesh, East Fork, and Little Salmon River populations (BPA et al. 2013, 2016, 2020). The Secesh River population is targeted for highly viable status, the East Fork for viable or maintained status, and the Little Salmon River population for maintained status in the ESA recovery plan (NMFS 2017a),[54] and improvements are needed in all of these populations to achieve their targeted status.

In summary, some habitat areas in the South Fork Salmon MPG are highly productive, and some degraded areas are likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices. In general, however, tributary habitat conditions are still degraded and continue to negatively affect spring/summer Chinook salmon abundance, productivity, spatial structure, and diversity. In addition, ongoing land-use activities are likely to have negative effects. There is potential for improvement in habitat productivity in all populations in this MPG, and additional improvements are needed to achieve recovery goals. In its most recent status review, NMFS recommended that future efforts focus on continuing to obliterate and decommission legacy roads and improve or relocate active roads, restoring riparian habitats, reducing impacts of recreational use, addressing fish passage barriers, and restoring degraded riparian and instream habitats. The review also highlighted the importance of developing adequately protective land management plans for Federal lands (NMFS 2016b).

2.2.2.4.3 Middle Fork Salmon River MPG

The Middle Fork Salmon MPG historically supported nine SR spring/summer Chinook salmon populations: Chamberlain Creek, Big Creek, the Lower Middle Fork Salmon River, Camas

[54] To achieve ESA recovery goals, the South Fork Salmon River and Secesh River populations must achieve viable or highly viable status; the East Fork Salmon River population must achieve viable or maintained status; and the Little Salmon River population must achieve maintained status (NMFS 2017a).

Creek, the Upper Middle Fork Salmon River, Sulphur Creek, Bear Valley Creek, Loon Creek, and Marsh Creek. All of these populations are extant (NMFS 2017a).

Public forestlands cover much of the Middle Fork Salmon River MPG, with large portions protected in the Frank Church—River of No Return Wilderness Area. As a result, much of the habitat in the area has little influence from contemporary land management activities, and most spawning and rearing habitat for these spring/summer Chinook salmon populations remains in good to excellent condition and protected from human impacts. For instance, the Chamberlain Creek, Big Creek, and Lower Middle Fork Salmon populations are entirely, or almost entirely, in the wilderness area; the Camas Creek, Loon Creek, Upper Middle Fork Salmon, and Sulphur Creek populations are mostly in the wilderness area; and the Bear Creek and Marsh Creek populations are predominantly on U.S. Forest Service lands and include some wilderness areas (NMFS 2017d).

For the most part, the habitat for these populations is high functioning. In non-wilderness portions of the Middle Fork Salmon River, including private inholdings within the wilderness, habitat has often been compromised by livestock grazing, water withdrawal, mining, road construction, and recreation. Even in the wilderness area habitats, localized areas display degraded habitat conditions associated with road development, past mining, livestock grazing, irrigation diversions, timber harvest, off-highway vehicles, and other recreational use. These localized limitations include impacts to passage, flow, sediment inputs, riparian area function, and nutrient supply. In addition, loss of beavers has led to channel simplification (NMFS 2016b, 2017d).

Some entities, primarily the U.S. Forest Service and the Nez Perce Tribe, have implemented actions such as mine rehabilitation, riparian restoration, road decommissioning, and culvert replacements targeted at addressing localized impacts for populations in this MPG. For example, a water diversion on Loon Creek was modified to improve passage to more than 13 miles of habitat, and a vehicle ford through spawning habitat in Big Creek was replaced with a bridge. In addition, in 2014, NMFS completed an ESA Section 7 consultation on three water diversions in Camas Creek, requiring the diversions to be screened and have regular flow monitoring (NMFS 2014c). In 2015, an ESA Section 7 consultation was completed for Federal grazing allotments in Camas Creek, eliminating overlap of livestock grazing with spawning Chinook salmon and requiring increased implementation and effectiveness monitoring (NMFS 2015b). The Action Agencies have implemented a very limited amount of habitat improvement actions in this MPG.

Best available science indicates that the actions have improved, and will continue to improve, habitat function in the targeted populations, but in general, opportunities to improve habitat in this MPG are more limited than in other MPGs in this ESU. Continuing to implement actions targeted toward addressing localized impacts may provide some additional benefits. It is also possible that other actions, such as reintroduction of beaver in populations with significant marsh habitat, could be beneficial, as could nutrient supplementation and management of non-native brook trout (NMFS 2017a, 2017d). However, further evaluation is needed to understand the potential for these actions to improve the function of spawning and rearing habitat and provide population benefits.

In summary, habitat in the Middle Fork Salmon MPG is generally of high quality due to the preponderance of wilderness areas and other Federal lands; there appears to be relatively low potential for improving habitat productivity in most populations in this MPG, although further exploration of the potential for improvement, and the best methods for improvement, is warranted and improvements are needed to achieve recovery goals.[55]

2.2.2.4.4 Upper Salmon River MPG

The Upper Salmon River MPG historically supported nine SR spring/summer Chinook salmon populations; North Fork Salmon River, Lemhi River, Upper Salmon River Lower Mainstem, Pahsimeroi River, East Fork Salmon River, Yankee Fork Salmon River, Valley Creek, Upper Salmon River Upper Mainstem, and Panther Creek. The Panther Creek population is extirpated; the other eight are extant (NMFS 2017a).

For most populations in this MPG, Federal lands managed by the U.S. Forest Service and Bureau of Land Management cover much of the upper elevation areas; lower elevation lands are under private ownership and overlap with significant areas of salmon spawning and rearing habitat. Land uses influencing habitat quality in the MPG include livestock grazing, timber harvest, agricultural practices, recreation, and mining; in many cases, the habitat impacts of these activities are extensive (NMFS 2017d). Much of the upper Salmon River basin is managed for public use, with some of the basin protected in wilderness or roadless areas, and habitats in this area tend to be of high integrity, whereas habitats tend to be more modified or degraded in the major watersheds that have broad valleys and easier access for humans and development, such as the lower Salmon, Pahsimeroi, and Lemhi watersheds (NMFS 2016b).

In both the Lemhi and Pahsimeroi Rivers, irrigation diversions have extensively modified habitat by disconnecting tributaries from the mainstem, or have otherwise substantially reduced availability of habitat. In the Yankee Fork, historical mining activities extensively and drastically modified habitat by removing vegetation, exposing and compacting soils, altering drainage patterns, modifying substrate, and disconnecting the river from its floodplain. In the Upper Salmon River Lower Mainstem, Upper Salmon River above Redfish Lake, North Fork, East Fork, and Valley Creek populations, salmon habitat has also been degraded by grazing, water diversions, residential development, and historical and current mining. In general, land uses in this MPG have reduced riparian function, channelized rivers and streams, disconnected floodplains and tributaries, created low flows, accelerated sediment loading, increased water

[55] The basic ICTRT viability criteria would require that the Big Creek, Loon Creek, Bear Valley, Marsh Creek, and Chamberlain Creek populations achieve viable or highly viable status; the Upper Middle Fork and Camas Creek populations achieve maintained or viable status; and the Lower Middle Fork and Sulphur Creek populations achieve at least maintained status. Overall at least five of the nine populations in this MPG need to be restored to viable status, with at least one demonstrating highly viable status, to achieve ESA recovery goals (NMFS 2017a). Improvements are needed in all of these populations to achieve their targeted status.

temperatures to critical levels, and caused entrainment of juvenile and adult fish in irrigation facilities. While legacy impacts of activities on public lands have generally been declining, impacts of land uses on private lands continue to be significant and to negatively affect the abundance, productivity, and spatial structure of the populations in this MPG (NMFS 2017d).

NMFS noted in its most recent status review that over 60 Federal grazing allotments in the upper Salmon River basin had undergone new ESA section 7 consultations since the previous status review, and that these allotments' management plans were revised, sometimes substantially, to reduce their individual and cumulative impacts on aquatic habitat and fish (2016b). In addition, many restoration activities have been carried out in this MPG through the individual and combined efforts of Federal, state, tribal, local, and private entities, including the Action Agencies. These actions have been targeted toward addressing the identified limiting factors and have included riparian fencing, planting, and streambank restoration; consolidating and reducing water diversions to improve efficiency and stream flow; improving stream structure and complexity; reconnecting tributaries and floodplains to the mainstem; improving spawning and rearing habitat access by removing barriers; and protecting habitat through acquisitions, conservation easements, and other cooperative landowner agreements (BPA et al. 2013, 2016, 2020; NMFS 2017d). Best available science indicates that these actions have improved, and will continue to improve, habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A).

An example of a coordinated, large scale effort to undertake restoration and monitor its results is the efforts carried out under the Intensively Monitored Watershed (IMW)[56] in the Lemhi Basin, described below:

- In the Lemhi River, insufficient instream flow, loss of access to historically important habitat, and simplification of mainstem habitat were the primary limiting factors for Chinook salmon and steelhead productivity (ISEMP/CHaMP 2015, 2016). Twenty-two types of habitat improvement actions were planned in high-priority watersheds. To date, tributary water diversions have been replaced with mainstem diversions, allowing tributaries to be reconnected to the mainstem, reducing total water withdrawals, and allowing cooler tributary water to enter the mainstem Lemhi River. In addition, tributary passage conditions have been improved, providing access to relatively intact public lands. The reconnection of tributaries to the Lemhi River has nearly doubled the length of stream available to Chinook salmon and steelhead (ISEMP/CHaMP 2016). Minimum

[56] An intensively monitored watershed (IMW) is an experiment in one or more catchment basin(s) with a well-developed, long-term monitoring program to determine watershed-scale fish and habitat responses to habitat restoration actions. The goals of the IMW approach are to determine the effectiveness of restoration actions at increasing salmon and steelhead productivity, determine the causal mechanisms of fish responses to restoration, and ultimately extrapolate the results to other watersheds where intensive monitoring is not possible due to limited budgets (Bennett et al. 2016).

instream flow agreements have addressed passage impediments and reduced temperatures in the upper mainstem Lemhi River.

- Overall, restoration has resulted in a 22 percent increase in wetted stream area and a 19 percent increase in pool habitat in the Lemhi River basin compared to pre-treatment conditions. Adult steelhead have moved into each of the five reconnected tributaries, and these tributaries are producing anadromous juveniles. Researchers have also documented the presence of adult Chinook salmon in two of the five reconnected tributaries, and juvenile Chinook salmon in all reconnected tributaries (Hillman et al. 2016, Haskell et al. 2019). This is the first occurrence of juvenile salmon in four of the five tributaries since the mid-2000s. The IMW team has reported an increase in juvenile Chinook salmon productivity (Uthe et al. 2017, Haskell et al. 2019). Overall, work in the Lemhi River basin has increased the summer rearing capacity for parr by 62 percent. Monitoring information and modeling results now indicate that juvenile Chinook salmon rearing habitat, particularly winter habitat, is currently limiting in the lower Lemhi River. As a result, habitat improvement efforts have shifted to improve habitat in the lower Lemhi River (Hillman et al. 2016).

The Action Agencies' efforts in this MPG under the 2008 and 2019 biological opinions were focused on the Lemhi, Pahsimeroi, Upper Salmon River above Redfish Lake, Valley Creek, and Yankee Fork populations (BPA et al. 2013, 2016, 2020). The Lemhi, Pahsimeroi, Valley Creek, East Fork Salmon River, and Upper Mainstem Salmon River populations are targeted for viable or highly viable status in the ESA recovery plan (NMFS 2017a). Ultimately, the Yankee Fork population will need to improve to "maintained" status to meet ESA recovery criteria (NMFS 2017a).

NMFS used a life-cycle model to assess the proposed action for this opinion (see Section 2.2.3.1.12). As part of this assessment, modelers evaluated the effects of tributary habitat actions implemented in 2009 through 2015 for populations in the Upper Salmon River MPG.[57] The model for the upper Salmon River populations evaluated the effects on juvenile rearing capacity and spawning capacity of instream actions (i.e., instream actions to improve stream complexity or floodplain/side-channel connectivity), and actions to improve access. Based on the model results, actions of this type implemented in 2009 through 2015 increased juvenile rearing capacity by 7 percent in the Lemhi, 9.4 percent in the Pahsimeroi, 2 percent in the North Fork, less than 1 percent in the East Fork and Upper Mainstem, and 1 percent in the Yankee Fork. The actions increased spawning capacity by less than 0.5 percent in most of these populations, and by 2.1 percent in the Lemhi population. Changes in abundance of natural-origin spawners and

[57] Although habitat improvement actions were underway in this ESU before 2009, modelers used 2009 as a starting point because they viewed actions completed before then as less likely to yield benefits, as a result of having been more opportunistic, smaller actions implemented without the benefit of comprehensive tributary and reach assessments and other planning tools. In addition, systematic monitoring data to describe habitat conditions for use in the life-cycle models were not available prior to 2009. The results represent a conservative estimate of the effects of actions implemented to date since they do not include actions completed in 2016 through 2019, actions for which modeling results were unavailable at the time of drafting this opinion.

extinction risk for these populations as a result of these actions are captured in the life-cycle modeling results discussed in Section 2.2.3.1.12. Because this model does not evaluate the effects of actions such as returning flow to the stream, screening diversions, and restoring riparian areas, benefits of such actions are not included in the modeled increases in capacity. Modeling methods, assumptions, and results are documented in Pess and Jordan, eds. (2019) and in Jordan et al. (2020). Further, the modeling may not have captured all benefits attributable to the specific actions that were evaluated.

A recent assessment evaluated capacity deficits for key life stages and bottlenecks in the quantity and quality of available connected habitats for spring Chinook salmon populations in this MPG. It concluded that across the Upper Salmon River MPG, deficits in available summer and winter juvenile rearing capacity are the primary factor limiting growth of populations, and that the adult spawning life stage is likely not limiting. Limiting factors associated with the lack of summer rearing habitat include inadequate habitat complexity. Limiting factors associated with the lack of winter rearing habitat include lack of concealment cover within low-velocity areas as a result of embedded substrate, lack of woody debris, lack of deep complex pools, and lack of undercut banks (Idaho OSC IRA Team 2019).

The assessment recommends actions that focus on increasing summer and winter rearing capacity by reducing width-to-depth ratios, increasing floodplain connectivity and complex habitat structure, increasing low- to zero-velocity pool habitat with cover, providing side channel habitat, and reducing sediment. Additional recommended actions include moderating water temperatures and instream flows by increasing hyporheic flow and alluvial aquifer connections and improving riparian habitat (Idaho OSC IRA Team 2019).

In summary, while some degraded areas in Upper Salmon River MPG are likely on an improving trend as a result of habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect spring Chinook salmon abundance, productivity, spatial structure, and diversity. There is high potential for additional improvement in habitat productivity in all populations in this MPG, and additional improvements are needed to achieve recovery goals.[58]

2.2.2.4.5 Grande Ronde/Imnaha Rivers MPG

The Grande Ronde/Imnaha Rivers MPG historically supported eight SR spring/summer Chinook salmon populations: Lostine/Wallowa, Upper Grande Ronde, Catherine Creek, Imnaha, Minam, Wenaha, Big Sheep Creek, and Lookingglass Creek. The Big Sheep and Lookingglass Creek populations are extirpated, leaving six extant populations (NMFS 2017a).

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[58] The basic ICTRT recovery criteria would require that the Lemhi, Pahsimeroi, East Fork Salmon, Valley Creek, and Upper Salmon above Redfish Lake populations achieve viable or highly viable status, and that the North Fork Salmon, Upper Salmon below Redfish Lake, and Yankee Fork populations achieve at least maintained status. Improvements are needed in all of these populations to achieve their targeted status. The Panther Creek population is extirpated and not required for recovery (NMFS 2017a, 2017e).

Habitat conditions vary across the six extant populations—some habitats are nearly pristine, while others are highly degraded. Habitat for the Wenaha and Minam populations is in good condition; nearly all the habitat for these populations is in designated wilderness areas, although some effects from past land use activities linger. Over two-thirds of the Imnaha River basin is also under public ownership. While habitat is in relatively good condition, limiting factors assessments have identified high temperatures, elevated levels of fine sediment, and reduced instream structure within the middle reaches of the mainstem Imnaha River as significant limiting factors. Habitat for the Lostine/Wallowa population is in mixed condition, ranging from nearly pristine in high-elevation reaches (which are in designated wilderness areas), to more modified conditions in some valley floor reaches. Habitat for the Catherine Creek and Upper Grande Ronde River populations is highly degraded. Overwintering habitat in lower and middle Catherine Creek reaches is also impaired. In the Upper Grande Ronde River population, lower elevation habitats that once supported spawning and rearing have also been extensively modified, primarily by livestock grazing and irrigated agriculture. Artificial barriers restrict passage in the Catherine Creek, Upper Grande Ronde River, and Imnaha River populations (NMFS 2017a, 2017e).

Impaired habitat conditions in this MPG generally stem from the combined effects of agricultural and grazing practices, forest management, dams and other barriers, water withdrawals, roads, and channel manipulations, particularly from practices in the late 19^{th} to mid-20^{th} centuries. These land uses have contributed to excess fine sediment, water quality impairment (primarily temperature), water quantity impairment (primarily low summer flows), and impaired habitat quantity/diversity (primarily limited pools and large wood). Sediment levels are also above historical levels throughout the area, except in wilderness area watersheds. Summer water temperatures are generally elevated in streams across the Grande Ronde River basin. Summer flows are lower than they were historically due to water withdrawals and land management practices. Large wood and pool habitat in streams across the area are reduced relative to historical levels. Many reaches also suffer from impaired riparian conditions and loss of floodplain connectivity, which contribute to the above conditions. Habitat conditions in the Grande Ronde River migration corridor (which also serves as rearing habitat) are also limited and affect primarily juvenile rearing and migration (NMFS 2017e).

Many restoration activities have been carried out for this MPG in recent years by Federal, state, tribal, local, and private entities, including the Action Agencies. Catherine Creek and the Grande Ronde Upper Mainstem are the most severely degraded habitats and have been a primary focus of effort; work has also been completed for the Lostine/Wallowa population. In Catherine Creek, work has focused on creating more summer rearing habitat and reducing relatively high juvenile mortality associated with downstream spring out-migration through the lower Catherine Creek mainstem/lower Grande Ronde Valley reach. In the Grande Ronde, efforts have focused on improving habitat complexity, restoring riparian areas in remaining available spawning and rearing habitat, and increasing floodplain function (NMFS 2014a; BPA et al. 2016, 2020).

Over time, these actions have been increasingly strategically targeted to address the limiting factors, and this should improve their effectiveness. For instance, Reclamation has completed tributary assessments in the Upper Grande Ronde River subbasin (BOR 2014) and Catherine Creek (BOR 2012). The Action Agencies have also funded and worked with local partners since 2011 to develop, implement, and adaptively manage the "Atlas" process, a systematic approach to identify and prioritize the actions that would be most likely to improve habitat. The Atlas process includes key elements from the watershed restoration principles articulated in Roni et al. (2002, 2008) and Beechie et al. (2008, 2010). It is a multi-criteria decision analysis framework that utilizes the best available empirical fish and habitat data; peer-reviewed, published research evidence; and local knowledge to determine the highest-priority areas and actions for habitat improvement within a watershed. It integrates geographical information system (GIS) data relating to the limiting factors in an assessment unit to identify "biologically significant reaches," and results in scored restoration opportunities, displayed on a map within a hierarchical spatial framework (Booth et al. 2016). The process builds on the tributary and reach assessments and other available data and information and is intended to improve the ability to identify opportunities for habitat improvement actions that address limiting factors. The Atlas process and other assessments have contributed to an enhanced understanding of habitat conditions and functions and of the potential for improvement in the studied reaches; together these tools are improving the Action Agencies' abilities to target habitat improvement actions where they will provide the greatest benefits.

Multiple projects have now been completed under the Atlas framework. As an example, the Atlas process revealed that habitat improvement targeted in the CCC3a and CCC3b assessment units of Catherine Creek would provide the best opportunities to address limiting factors for that population. The Action Agencies and their partners have since focused implementation in those areas. The Southern Cross project, for instance, located in CCC3b, presented one of the most significant opportunities to restore core spawning and rearing habitat for Catherine Creek spring/summer Chinook salmon. The project's goal was to restore watershed processes and functions and address habitat limiting factors, including flow, passage, temperature, channel/floodplain conditions, habitat complexity and diversity, and riparian/wetland communities to improve summer and winter rearing conditions for juvenile salmonids and holding habitat for adult Chinook salmon.

Completed in 2017, the Southern Cross project included acquisition of 545 acres (through the Confederated Tribes of the Umatilla Indian Reservation [CTUIR]-BPA Accord), realigning Catherine Creek into a sinuous, lower gradient channel connected to its historical floodplain, and constructing a network of floodplain swales and channels. Habitat features included large wood, constructed riffles, alcoves, and large pool habitat. The project created 4,200 linear feet of new main channel: 995 linear feet of perennial side channel, 425 linear feet of new ephemeral side channel, 1,425 linear feet of alcoves and spring channels; 9,200 linear feet of floodplain wetland complexes, and 15 riffles in the main channel. It also added 142 main channel wood structure components: 570 linear feet of edge roughness, 1,075 feet of brush mattress, and 336 floodplain roughness features. Monitoring by the CTUIR has documented increased Chinook salmon and steelhead juvenile rearing densities in the project area since completion, and the Oregon Department of Fish and Wildlife (ODFW) documented the highest juvenile chinook salmon rearing densities within the project compared to 10 sample locations distributed throughout core Catherine Creek anadromous fish spawning and summer rearing reaches (CTUIR 2018, 2019).

Best available science indicates that the actions implemented by the Action Agencies and other entities have improved, and will continue to improve, habitat function, and that fish population abundance and productivity will respond positively. The benefits of some of these actions will continue to accrue over several decades (Appendix A). To achieve recovery under the ESA recovery plan, the Lostine/Wallowa and Catherine Creek populations must achieve viable or highly viable status, and the Grande Ronde population must improve to viable or maintained status.

NMFS used a life-cycle model to assess the proposed action (see Section 2.2.3.1.12). As part of this assessment, modelers evaluated the effects of actions implemented in 2009 through 2015 for populations in the Grande Ronde/Imnaha Rivers MPG.[59] Modeling methods, assumptions, and results are documented in Pess and Jordan, eds. (2019) and Cooney et al. (2020b). In Catherine Creek, for example, actions implemented from 2009 to 2015 were designed to increase flows in key rearing reaches and to increase the amount of functional pool habitat through stream structure improvements and side-channel reconnections. Actions also included some riparian restoration in reaches with high summer stream temperatures that currently impair or inhibit summer rearing. Some of these actions (e.g., those designed to improve stream structure and floodplain connectivity) should yield benefits in the relatively short term, while benefits of other actions (e.g., riparian restoration) would accrue over a longer time frame. The most limiting life stage that would be affected by the actions is summer parr rearing capacity. Modelers concluded that the 2009 to 2015 actions would increase summer parr rearing capacity by 21 percent within a few years of implementation. They also concluded that, while the temperature reductions associated with shading would not be fully realized for several decades, shading levels would be expected to start contributing to reducing temperatures after 5 to 10 years. Changes in abundance of natural-origin spawners and extinction risk for these populations as a result of these actions are captured in the life-cycle modeling results discussed in Section 2.2.3.1.12. Further, the modeling may not have captured all benefits attributable to the specific actions that were evaluated.

In summary, while some degraded areas in the Grande Ronde/Imnaha Rivers MPG are likely on an improving trend, as a result of habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect

[59] Although habitat improvement actions were underway in this ESU before 2009, modelers used 2009 as a starting point because they viewed actions completed before then as less likely to yield benefits, as a result of having been more opportunistic, smaller actions implemented without the benefit of comprehensive tributary and reach assessments and other planning tools. In addition, systematic monitoring data to describe habitat conditions for use in the life-cycle models were not available prior to 2009. The results represent a conservative estimate of the effects of actions implemented to date since they do not include actions completed in 2016 through 2019, actions for which modeling results were unavailable at the time of drafting this opinion.

spring/summer Chinook salmon abundance, productivity, spatial structure, and diversity. There is a high potential for improvement in habitat productivity in several populations in this MPG, including three out of four populations targeted for viable status in the ESA recovery plan, and additional improvements are needed to achieve recovery goals.[60] Ongoing land-use activities are likely to continue to have negative effects.

2.2.2.4.6 Lower Snake River MPG

The Lower Snake River MPG historically supported two SR spring/summer Chinook salmon populations: Tucannon River and Asotin Creek. The Asotin Creek population is extirpated, leaving the one extant population (NMFS 2017a).

For this MPG, historical and current land use practices, including grazing and irrigated agriculture, logging, removal of beaver populations, roads, residential development, and diking, have led to excess fine sediment, diminished large wood supply, channel straightening and confinement, degraded riparian function, increased summer water temperatures, diminished flows, and passage impairments at artificial barriers and diversions. These factors have diminished habitat diversity and the availability of key habitat, particularly summer rearing and overwintering capacity, and have negatively affected the abundance, productivity, and spatial structure of spring Chinook salmon (Snake River Salmon Recovery Board 2011, NMFS 2017a).

Many restoration activities have been carried out for this MPG in recent years by Federal, state, tribal, local, and private entities, including the Action Agencies. These actions have been targeted toward addressing identified limiting factors and have included large-scale efforts to enhance stream complexity and restore floodplain function and side-channel complexity through placement of logjams, riparian restoration, levee removal, and side-channel reconnection (Snake River Salmon Recovery Board 2011; BPA et al. 2013, 2016, 2020; NMFS 2014a).

Here too, actions have been increasingly strategically targeted over time. Initially after the listing of SR spring/summer Chinook salmon, in 1992, habitat improvement efforts in the Tucannon River basin were focused on removing fish passage barriers, screening diversions, reducing fine sediments, improving stream flow, and addressing high summer water temperatures. In 2011, in an effort to develop a coordinated approach to restoration in priority reaches of the Tucannon River, BPA began funding the Tucannon River Habitat Programmatic Project. Under this programmatic, the Tucannon Geomorphic Assessment and Restoration Study (Anchor QEA 2011) was developed, followed by restoration plans for specific reaches. Based on these planning documents, habitat improvement efforts were refined to focus on lack of floodplain connectivity, loss of riparian forest and channel complexity, excess stream power, and a lack of large deep pools where adult salmonids could hold before spawning. These issues are the result of past

[60] The basic ICTRT viability criteria would require that the Wenaha, Minam, Lostine/Wallowa, Catherine Creek, and Imnaha populations achieve either viable or highly viable status and that the Upper Grande Ronde population achieve either viable or maintained status. Overall, at least four populations should meet viability criteria, with at least one highly viable; the rest should meet maintained status (NMFS 2017a). Improvements are needed in all of these populations to achieve their targeted status.

floodplain management, including construction of levees that have confined and straightened the river and created incised channels throughout the watershed. Actions have resulted in improving trends, including:

- Increased accessibility to suitable habitat in headwater streams via passage improvement.
- Improved stream channel stability.
- Decreased channel width-to-depth ratios, gradient, and entrenchment.
- Increased sinuosity, length, and floodplain connection.
- Enhanced pool habitat.
- Increased shade and undercut banks.
- Increased availability of instream habitat, including off-channel rearing areas.
- Increased instream habitat complexity and diversity, resulting in improved pool-riffle sequences associated with dynamically stable channel morphology.

Best available science indicates that these actions have improved, and will continue to improve, habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. The benefits of some of these actions will continue to accrue over several decades (see Appendix A). For ESA recovery, the Tucannon River population, the only extant population in the MPG, must achieve highly viable status (NMFS 2017a).

In summary, while some degraded areas in the Tucannon River basin are likely on an improving trend as a result of ongoing habitat improvement actions and improved land use practices, in general, tributary habitat conditions are still degraded and continue to negatively affect the abundance, productivity, and spatial structure of the single extant population in this MPG. There is a high potential for improvement in habitat productivity in the Tucannon River population, and additional improvements are needed to achieve the population’s targeted recovery status of highly viable. Ongoing land-use activities are likely to continue to have negative effects.

2.2.2.4.7 ESU Summary

In summary, while tributary habitat conditions in the SR spring/summer Chinook salmon ESU are likely improving in some areas as a result of habitat improvement actions and improved land use practices, in general, tributary habitat conditions are still degraded and continue to negatively affect SR spring/summer Chinook salmon abundance, productivity, spatial structure, and diversity. The potential exists to further improve tributary habitat capacity and productivity in this ESU, although the potential appears to be limited in some populations. Additional improvements are needed in almost all populations to achieve recovery goals. In addition, ongoing development and land-use activities are likely to continue to have negative effects.

2.2.2.5 Estuary Habitat

The Columbia River estuary provides important migratory habitat for yearling SR spring/summer Chinook salmon. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review (NMFS 2016b), have improved access and connectivity to floodplain habitat. From 2007 through 2019, the Action Agencies implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents more than a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling Chinook salmon (Johnson et al. 2018). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Floodplain habitat restoration can affect the performance of juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) are also exported to the mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Thus, while most yearling Chinook salmon may not enter a tidal wetland channel, they still derive benefits from wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry. Blood serum levels of insulin-like growth factor-1 (IGF-1) for yearling spring and summer Chinook salmon collected in the estuary were higher than are typically found in hatchery fish before release, suggesting that prey quality and quantity in the estuary were sufficient for growth (PNNL and NMFS 2020). However, variation in IGF-1 levels was substantial (two to three times higher in some individuals than in others) (Beckman 2020), both within and between genetic stocks, indicating differences in feeding and migration patterns. Continuing to grow during estuary transit may be part of a strategy to escape predation during the ocean life stage through larger body size.

As discussed in Section 2.2.2.1.2 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetation can shift the composition of biological communities, create favorable conditions for invasive, pollution-tolerant plants and animals, and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.2.2.6 Predation

A variety of avian and fish predators consume juvenile SR spring/summer Chinook salmon on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. This section discusses predation rates and describes management measures to reduce the effects of the growth of predator populations within the action area.

2.2.2.6.1 Avian Predation

Avian Predation in the Lower Columbia River Estuary

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge to the lower river, especially during spring, contributes to reduced turbidity, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including SR spring/summer Chinook salmon) in the Columbia River. Caspian terns *(Hydroprogne caspia)* on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island, where the tern diet would diversify to include marine forage fish. During 2001 to 2015, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction from when the colony was on Rice Island.

Based on PIT-tag recoveries at East Sand Island, average annual Caspian tern and double-crested cormorant *(Phalacrocorax auratus)* predation rates for this ESU were about 5.2 and 4.6 percent, respectively, before efforts to manage the size of these colonies (Evans and Payton 2020). Tern predation rates have decreased to 2.1 percent since 2007, a statistically credible difference (Appendix B). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on SR spring/summer Chinook salmon in 2003 to 2014 was 4.6 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[61] where smolts are likely to constitute a larger proportion of the diet. The average annual predation rates on SR spring/summer Chinook salmon reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (6.8 during 2015 to 2017 and 0.5 percent in 2018) therefore cannot be directly compared to those before management began and are likely to underestimate predation rates in the estuary (Appendix B).

Avian Predation in the Hydrosystem Reach

The following paragraphs describe avian predation in the mainstem lower Snake and Columbia Rivers from Bonneville Dam to the head of Lower Granite Reservoir.

SR spring/summer Chinook salmon survival in the mainstem is affected by avian predators that forage at the mainstem dams and reservoirs. The 2008 biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84 to 94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the

[61] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[62]

Juvenile SR spring/summer Chinook salmon are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been focused on keeping terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015, and similar efforts by Reclamation are in progress at Goose Island. Predation rates on this ESU on Crescent, Goose, and North Potholes Islands were less than 1 percent both before and after implementation of the IAPMP, so that reducing the size of those colonies has probably had little effect on the survival of juvenile SR spring/summer Chinook salmon. Predation rates at the Blalock Islands in John Day Reservoir were also less than 1 percent both before and after implementation of the IAPMP.

Predation by gulls was not considered to warrant management actions at the time the IAPMP was developed, and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this ESU by gulls on Miller Rocks averaged 1.2 percent during 2007 to 2019 (Evans and Payton 2020) (Appendix B). Predation rates on SR spring/summer Chinook salmon were less than 2 percent per colony for gulls nesting on Island 20 and Badger, Crescent, and Blalock Islands in recent years (Evans and Payton 2020).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on SR spring/summer Chinook salmon after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts overestimates the conservation benefit in terms of adult returns because of compensatory behavior either of the prey (e.g., density dependence) or another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between

[62] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams" (Zorich et al. 2012).

predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead, and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different but related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., had no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns (an additive effect). But the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, also will be important.[63]

With respect to management of terns in the estuary, Caspian terns nesting on East Sand Island were eating an annual average of 5.2 percent of the juvenile SR spring/summer Chinook salmon outmigrants before management actions reduced the size of that colony, and 2.1 percent per year thereafter, a statistically credible difference (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (5.2 percent), the average 3.1 percent per year decrease achieved by reducing the size of the tern colony, and that some level of compensation is likely to occur in the ocean even in favorable ocean years, it is likely that this management measure did not lead to increased adult returns for this ESU. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 4.6 percent to less than 1 percent. However, in this case, predation rates on SR spring/summer Chinook salmon are likely to have increased because thousands of these birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[64]

2.2.2.6.2 Fish Predation

The native northern pikeminnow (Ptychocheilus oregonensis) is a significant predator of juvenile salmonids in the Columbia and Snake Rivers followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP

[63] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

[64] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (*Haliaeetus leucocephalus*) (Appendix B) and cannot be attributed to the management measures alone.

in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 millimeter [mm] fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). From 2015 to 2019, an annual average of 43 adult, 18 jack, and 104 juvenile Chinook salmon were incidentally caught in the Sport Reward Fishery (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were SR spring/summer Chinook salmon.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). They also reported an average of one adult and zero juvenile Chinook salmon killed or handled per year. In addition, they caught, but did not remove, an annual average of 967 smallmouth bass and 379 walleye at the two dam angling sites combined over the last 5 years (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). The Oregon and Washington Departments of Fish and Wildlife, which manage these two non-native predator species, are currently discussing the possibility of removing smallmouth bass and walleye from the system when captured by the Dam Angling Program (as with pikeminnow). Both agencies have already removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these species, in addition to pikeminnow, both in the lower Columbia River and the CRS reservoirs (i.e., hydrosystem reach), would incrementally improve juvenile salmonid survival during their migration to the ocean.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile Chinook salmon, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. Williams et al. (2018) found a lower than average abundance (1990 to 2018) for northern pikeminnow in The

Dalles and John Day Reservoirs along with a two to three times higher than average abundance for smallmouth bass and walleye in the same reservoirs. With the exception of the John Day forebay area, smallmouth bass abundance index values calculated for 2018 were the highest observed since 1990. Abundance index values provide a means to characterize relative predation impacts (Williams et al. 2018). Similarly, in 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP, as well as a substantial increase in their predatory impact in the lower Snake reservoirs since program design and implementation. Also compared to previous years, walleye were relatively abundant in both The Dalles and John Day Reservoirs during 2018 spring sampling, but few were encountered during the summer sampling. The greatest walleye abundance indices were observed in the John Day Dam tailrace and mid-reservoir, with the tailrace value being the highest recorded abundance to date (Williams et al. 2018). These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal still remains unclear. The complexity of inter-species interactions, combined with inter-reservoir variability and environmental variability, make this a difficult research question to answer without a more intensive sampling and evaluation program (Williams et al. 2018; Winther et al. 2019). However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the Chinook salmon that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including SR spring/summer Chinook salmon. As such, it likely continues to benefit the ESU.

2.2.2.6.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the Marine Mammal Protection Act (MMPA) was enacted in 1972 (Carretta et al. 2013). California sea lions *(Zalophus californianus)*, Steller sea lions *(Eumetopias jubatus)*, and harbor seals *(Phoca vitulina)* all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. The ODFW counted the number of individual California sea lions hauling out in the Columbia River mouth at the East Mooring Basin in Astoria, Oregon, from 1997 through 2017. Individual pinniped counts at East Mooring Basin have steadily increased since the inception of the observation program with rapid increases within the last decade. Within the Columbia River, the abundance of pinnipeds peaks in the spring when SR spring/summer Chinook salmon adults are migrating through the estuary.

Based on a recent 5-year mark-recapture study, average mortality of adult spring Chinook salmon through the estuary ranged from 20 to 44 percent annually, with survival lowest during the last 2 years of the study when pinniped abundance was highest. While all the mortality is not attributable to pinnipeds, the researchers found strong evidence that recent increases in spring Chinook salmon loss estimates were a function of the large increase in pinnipeds, and that earlier migrating populations suffered the greatest losses to pinnipeds (Rub et al. 2019).

Pinniped presence in the Bonneville Dam tailrace generally increased from 2002 to a peak in 2015, but declined substantially in the spring of 2019 (Tidwell et al. 2020). Rub et al. (2018) found that up to 50 percent of the mortality from pinnipeds of adult spring-run Chinook salmon (all ESUs) destined for tributaries above Bonneville Dam occurred within the 10-mile reach just below the dam. Hydroelectric dams can delay upstream fish passage and congregate fish searching for ladder entrances (Kareiva et al. 2000, Quinones et al. 2015). Such delays can make fish vulnerable to predation by pinnipeds (Stansell 2004, Naughton et al. 2011). Sea lion excluder gates are designed to reduce predation vulnerability and are installed at all eight ladder entrances at Bonneville Dam.

Biologists have been estimating spring Chinook salmon consumption by pinnipeds directly below (2 km) Bonneville Dam since 2002 (Tidwell et al. 2020). Based on tailrace predation monitoring efforts conducted from 2002 to 2019 at the Bonneville Dam tailrace, pinniped predation on all ESUs of spring Chinook salmon has been variable, but has generally decreased in the past 3 years, and we assume that predation of SR spring/summer Chinook salmon is similar. Tidwell et al. (2020) report that an estimated 1,974 spring Chinook salmon (all ESUs) were consumed by both pinniped species in 2019, which equates to 3.1 percent of the adult spring Chinook salmon that passed. Consumption rates of spring Chinook salmon in the last 3 years have ranged from 2.9 to 4.6 percent and have been declining since 2016, which was the highest consumption rate observed (Table 2.2-13). This reduction in spring Chinook consumption is likely the result of declining numbers of pinnipeds observed in the tailrace in the spring since 2015.

Table 2.2-13. Consumption of spring Chinook salmon by pinnipeds at Bonneville Dam tailrace from January 1 through May 31, 2002 to 2019. Passage counts of Chinook salmon include both adult and jack salmon.

Year	Bonneville Dam Spring Chinook Passage	Chinook Salmon Consumption Estimate	% Run
2002	275,290	880	0.3%
2003	210,028	2,313	1.1%
2004	179,193	3,307	1.8%
2005	78,341	2,742	3.4%
2006	99,366	2,580	2.5%
2007	83,252	3,403	3.9%
2008	143,139	4,501	3.0%
2009	181,174	4,360	2.3%

Year	Bonneville Dam Spring Chinook Passage	Chinook Salmon Consumption Estimate	% Run
2010	257,036	5,909	2.2%
2011	218,092	3,634	1.6%
2012	165,681	1,959	1.2%
2013	117,165	2,710	2.3%
2014	214,177	4,576	2.1%
2015	233,794	10,622	4.3%
2016	148,357	9,222	5.9%
2017	101,734	4,951	4.6%
2018	94,350	2,813	2.9%
2019	61,385	1,974	3.1%

Based on evidence of high rates of predation on SR spring/summer Chinook salmon (and other ESUs), NMFS has provided the states of Oregon and Washington with a Letter of Authorization under the Marine Mammal Protection Act to haze pinnipeds and remove California sea lions through June 30, 2021. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019 respectively (Tidwell et al. 2018, 2020).

The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between RM 112 and McNary Dam (RM 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

2.2.2.7 Research, Monitoring, and Evaluation Activities

The primary effects of the past and present CRS-related RME program on SR spring/summer Chinook salmon are associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish. The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods that can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass, and walleye throughout the system to evaluate the program's effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were SR spring/summer Chinook salmon. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the SR spring/summer Chinook salmon ESU by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of SR spring-summer Chinook salmon that have been handled (or have died) each year using the average annual take reported from 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of SR spring/summer Chinook salmon associated with the Smolt Monitoring Program and the CSS were as follows:
  - One hatchery and one natural-origin adult were handled.
  - One hatchery and one natural-origin adult died.
  - 44,912 hatchery and 22,882 natural-origin juveniles were handled.
  - 73 hatchery and 36 natural-origin juveniles died.
- Average annual estimates for SR spring/summer Chinook salmon handling and mortality for all other fish RME programs were as follows:
  - 7,679 hatchery and 2,310 natural-origin adults were handled.
  - One hatchery and two natural-origin adults died.
  - 42,608 hatchery and 44,853 natural-origin juveniles were handled.
  - 17 hatchery and 137 natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) of SR spring/summer Chinook salmon associated with these elements of the RME program has, on average, affected 21.4 percent of the natural-origin adult (recent, 5-year average) run (arriving at Lower Granite Dam) and 6.1 percent of naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects SR spring/summer Chinook salmon.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the ESU level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions, which are key components of effective adaptive management programs.

2.2.2.8 Critical Habitat

The condition of SR spring/summer Chinook salmon critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized here in Table 2.2-

14. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for SR spring/summer Chinook salmon production have been weakened. Conditions in the hydrosystem reach were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for SR spring/summer Chinook salmon have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.2-14. Physical and biological features of designated critical habitat within the action area for SR spring/summer Chinook salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Condition of the PBF in the Action Area
Spawning and juvenile rearing sites	Spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, space	Tributary barriers (culverts, dams, water withdrawals, unscreened water diversions) have reduced access to freshwater spawning and rearing sites for most populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning and rearing sites for most populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning and rearing sites for most populations. Excessive sediment in spawning gravel (forest and agricultural practices, mining, livestock on soft riparian soils and streambank, recreation) has reduced the quality of freshwater spawning and rearing sites for most populations. Diminished stream flow (water withdrawals, drought), has reduced the quantity and quality for freshwater spawning and rearing sites for most populations Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced water quality of freshwater spawning and rearing sites for most populations. Many tributary habitat improvement actions implemented in

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Condition of the PBF in the Action Area
		the Snake River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to spawning and rearing habitat.
Adult and juvenile migration corridors	Substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food (juveniles), riparian vegetation, space, safe passage	*Effects on migration corridor PBFs apply to all populations and MPGs of SR spring/summer Chinook salmon:* Alteration of the seasonal flow regime in the Columbia and lower Snake Rivers with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph has had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderately negative effect in lower flow years. Alteration of the seasonal mainstem temperature regime in the Columbia and Snake Rivers due to thermal inertia associated with the existence of the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in late summer and fall (hydrosystem development and operation).[1] In general, cooler spring temperatures do not adversely affect the functioning of the mainstem as a migration corridor for spring-run Chinook salmon. However, water quality is negatively affected for summer-run adults, which enter the lower Columbia River in June and July. Reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume (hydrosystem development and operation), may have reduced "natural cover" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining). The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable lubricants" where feasible. Increased exposure of juveniles to TDG in the lower Snake and Columbia Rivers and at least 35 miles below Bonneville Dam during involuntary[2] and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor for juvenile spring/summer Chinook salmon. The incidence of adverse effects (GBT in juveniles

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Condition of the PBF in the Action Area
		and adults) appears to have been small (1 to 2 percent) in recent years with TDG up to 120 percent. The existence and operation of the hydrosystem has reduced the safe passage PBF by creating conditions that delay and injure/kill some juveniles and a smaller proportion of adults in the migration corridor. However, the functioning of the safe passage PBF has increased substantially for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult spring/summer Chinook salmon during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past the dams or overwintering within the fish facilities or turbine units). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile spring/summer Chinook salmon because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems). Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for avian and fish predators in the tailraces of mainstem dams. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, propane cannons, and limited amounts of lethal take. Fish predation is addressed by dam angling at several dams. Delays of adults at the ladder entrances at Bonneville Dam has increased the risk of pinniped predation (excessive predation related to hydrosystem development and operation) in the migration corridor. Pinniped predation is addressed by the use of sea lion excluder devices and hazing at the fishway entrances at Bonneville Dam.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Condition of the PBF in the Action Area
		Diking off areas of the estuary flood plain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling Chinook salmon by more than 2.5 percent. Another 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the Caspian Tern Management Plan on East Sand Island is reducing excessive predation in the migration corridor, but depending on ocean conditions and compensatory effects, may not be increasing adult returns for SR spring/summer Chinook salmon. Implementation of the Double-crested Cormorant Management Plan may have contributed to, or at least coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Spill is characterized as "involuntary" when water is spilled over a dam's spillway because it cannot be stored in a reservoir behind the dam or passed through turbines to generate electricity, such as during maintenance activities, periods of low energy demand, or periods of high river flow. Involuntary spill is most common in the spring.

Habitat quality in tributary streams in the lower Snake River basin within the Interior Columbia Recovery Domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the area has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the Interior Columbia Recovery Domain (NMFS 2016b). As discussed above, many tributary habitat improvement actions have been implemented throughout the Snake River basin by Federal, tribal, state, local, and private entities. The Action Agencies' tributary habitat program has been protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. These actions are improving the condition of PBFs in specific locations.

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho's Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable spawning and rearing habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, withdrawal of water for agricultural or municipal use, and periodic droughts have all contributed to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016b). They can negatively impact critical habitat and the organisms associated with these areas.

The general effects of tributary dams on the functioning of critical habitat in spawning and rearing areas and migratory corridors for SR spring/summer Chinook salmon are:

- Lost access to historical spawning areas behind dams built without fish passage facilities (reduced safe passage).
- Altered juvenile and adult passage survival at dams with passage facilities (reduced safe passage).
- Altered flows and seasonal timing (reduced water quantity).
- Altered seasonal temperatures and elevated dissolved gas (reduced water quality).
- Reduced sediment transport and turbidity (reduced water quality).
- Altered food webs, including both predators and prey (reduced prey production and increased numbers of predators, including non-natives).

Habitat quality of migratory corridors in this area was substantially affected by the development and operation of the CRS dams and reservoirs in the mainstem lower Snake and Columbia Rivers, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and upper Columbia River basins. Hydrosystem development modified natural flow regimes, resulting in warmer late summer/fall water temperatures. Changes in fish communities led to increased rates of piscivorous predation on juvenile salmon and steelhead. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines, have delayed migration for both adults and juveniles. Turbines and juvenile bypass systems have also killed some out-migrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented measures in the juvenile and adult migration corridor including 24-hour volitional spill, surface passage routes, upgrades to juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

In addition, basinwide water management activities, including the operation of the CRS water storage projects for flood control, power generation, and water withdrawals have substantially reduced average monthly flows at Bonneville Dam during May to July and increased them during October to March compared to an unregulated system. Reduced spring flows, combined with the existence of mainstem dams, increased travel times during the juvenile outmigration period for SR spring/summer Chinook salmon, increasing the risk of predation. Since salmon and steelhead were listed and critical habitat was designated under the ESA, the Action Agencies have made substantial changes to minimize these operational effects by limiting storage reservoir elevations to minimums needed for flood risk management and passing more water during the spring refill period. By taking these actions, the Action Agencies have increased flows in the spring and summer, which helps replicate the natural hydrograph. As a result, the functioning of the migration corridor has been improved by reduced exposure to predators, increased turbidity (which can provide visual cover), and increased access to cover and prey in nearshore mainstem habitat.

The functioning of juvenile rearing and migration habitat for SR spring/summer Chinook salmon in the lower Columbia River estuary has been reduced by the conversion of more than 70 percent of the original marshes and spruce swamps to industrial, transportation, recreational, agricultural, or urban uses. Water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. Reduced sediment delivery to the lower river and estuary, combined with in-water structures that focus flow in the navigation channel and bank armoring, have altered the development of habitat along the margins of the river. All of these changes have reduced the availability of prey for smolts between Bonneville Dam and ocean entry.

In the hydrosystem reach, altered habitats in project reservoirs and tailraces create more favorable habitat conditions for fish predators; the latter include native northern pikeminnow and non-native walleye and smallmouth bass. The effects of the non-native species and those of pikeminnow, to the extent they are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea lion predation on adult SR spring/summer Chinook salmon in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary has increased, but is a natural phenomenon and therefore not excessive predation in the context of effects on the functioning of critical habitat.

Restoration activities in tributary spawning and rearing areas and in the estuary that are addressing habitat quality and complexity, and improved functioning of the juvenile migration corridor (e.g., 24-hour and flexible spill, new surface passage structures, and improved spillway designs) have improved the baseline condition for some components of the PBFs. However, the role of critical habitat is to provide PBFs that support populations that can contribute to the conservation of the ESU. More restoration is needed before the PBFs can fully support the conservation of SR spring/summer Chinook salmon.

2.2.2.9 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year status review evaluated new information regarding the status and trends of SR spring/summer Chinook salmon, including recent biological opinions issued for the SR spring/summer Chinook salmon, and key emergent or ongoing habitat concerns (NMFS 2016b). From January 2015 through May 22, 2020, we completed 557 formal consultations that addressed effects to SR spring/summer Chinook salmon.[65] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat, improve riparian conditions, and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., safe passage in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in

[65] Public Consultation Tracking System (PCTS) data query July 31, 2018; Environmental Consultation Organizer (ECO) data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.2.2.10 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of SR spring/summer Chinook salmon populations. Recent improvements in passage conditions at mainstem CRS dams, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, tributary habitat improvements, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. The recovery plan identified tributary and estuary habitat degradation, hydropower systems, harvest, hatcheries, predation, toxic contaminants, climate change, and fluctuating ocean cycles as limiting factors that continue to negatively affect SR spring/summer Chinook salmon populations (NMFS 2017a).

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for SR spring/summer Chinook salmon, as described above. The PBFs essential for the conservation of this species include freshwater spawning and rearing areas and juvenile and adult migration corridors, including the estuary. The Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of these critical habitat PBFs. For example, surface passage structures and spill operations have reduced obstructions for juvenile SR spring/summer Chinook salmon at CRS dams.

Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. Similarly, projects that have protected or restored tributary habitat have improved the functioning of the freshwater spawning and rearing sites. However, the factors described above continue to have negative effects on these PBFs.

2.2.3 Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species

(e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.2.3.1 Effects to Species

2.2.3.1.1 Spill and Seasonal Flow Operations

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams. The intent of flexible spill operations is to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem.[66] Spring spill operations will occur from April 3 to June 20 at the four lower Snake River projects and from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, the four lower Snake River dams and McNary Dam will all operate up to 125 percent TDG spill ("gas cap spill") for a minimum of 16 hours per day, and each project may operate under lower spill levels ("performance standard spill") for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill at all hours. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs maximum spill constraint) for 16 hours per day with 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours; however, once the trigger for adult SR spring/summer Chinook salmon passing Lower Monumental Dam is met,[67] 8 consecutive hours of performance standard spill will be used in the morning at Little Goose Dam to help reduce passage delays of adult SR spring/summer Chinook salmon.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan, unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in performance standard spill periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.2-15.

[66] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

[67] A passage trigger of 25 adult SR spring Chinook passing Lower Monumental Dam was implemented in 2020 per the Flexible Spill Agreement.

Table 2.2-15. Spring spill operations at lower Snake and Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3, 5]	Performance Standard Spill (8 hours per day)[2, 4, 5]
Lower Granite[5]	125% Gas Cap	20 kcfs
Little Goose[6, 7]	125% Gas Cap	30%
Lower Monumental	125% Gas Cap (uniform spill pattern)	30 kcfs (bulk spill pattern[8])
Ice Harbor	125% Gas Cap	30%
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[9]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[10]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility (with the exception of Little Goose and Lower Granite operations described in the notes that follow). Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions, except as noted below.

[5] Lower Granite Exception One - If adult passage delays are observed at Lower Granite Dam, the Corps may implement performance standard spill at Lower Granite Dam for at least 4 hours in the AM (beginning near dawn). Implementation of this modification may also trigger in-season reevaluation of options to balance power principle.

[6] Little Goose Exception One - As soon as practicable (and, in any event, no more than 24 hours) after a cumulative total of 25 adult spring Chinook salmon (not including jacks) pass Lower Monumental Dam, operate Little Goose spill at 30 percent spill for 8 consecutive am hours (April 1 to 15, start at 5 AM; April 16 to June 20, start at 4 AM).

[7] Little Goose Exception Two - During periods of involuntary spill, spill at 30 percent for 8 hours/day during the hours described in footnote 6 above and store additional inflows that exceed hydraulic capacity in the forebay above MOP if necessary. When it is necessary to pond water to achieve the lower spill levels due to high inflow, water stored above MOP should be drafted out over the remaining hours by increasing spill to pass inflow from 1200 to 1600 hours (or 1300 to 1700 hours from April 3 to 15), then increasing spill as necessary from 1600 to 0400 (or 1700 to 0500 hours from April 3 to 15) to draft the pool back to MOP. If it is forecast that the drafting spill will generate TDG levels in the tailrace in excess of 130 percent TDG, use all 16 hours to return the pool to MOP.

[8] If the specified spill level at bulk pattern exceeds the gas cap, then spill pattern will be changed to uniform.

[9] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[10] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 21 to August 31 at the four lower Snake River projects, and June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.2-16. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Snake and Columbia Rivers. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.2-16. Target summer spill levels at lower Snake and lower Columbia River projects.

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
Lower Granite[2,3]	18 kcfs	Removable spillway weir or 7 kcfs
Little Goose[2,3]	30%	Adjustable spillway weir or 7 kcfs
Lower Monumental[2,3]	17 kcfs	Removable spillway weir or 7 kcfs
Ice Harbor[2,3]	30%	Removable spillway weir or 8.5 kcfs
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[4]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] Spill levels may not be achievable on all hours if water is stored or flows are below 20 kcfs, which can occur in the month of August, especially at Lower Granite and Lower Monumental Dams when flows are at or below 30 kcfs (see FOP for additional information).

[3] Summer spill from August 15-August 31 may be through the spillway weir or through conventional spillbays using the appropriate FPP spill pattern for each project. The spillway weirs will be operated consistent with operational criteria in the FPP.

[4] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March, decreased flows from May through August, and little change in flows in April and September) described in the Environmental Baseline section will continue to affect the lower Snake and lower Columbia mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak Reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in all project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce high TDG events associated with spill in the winter, which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. The proportional effect on flow is higher in the lower Snake River than in the lower Columbia River due to its smaller flow volume. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.2-9).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

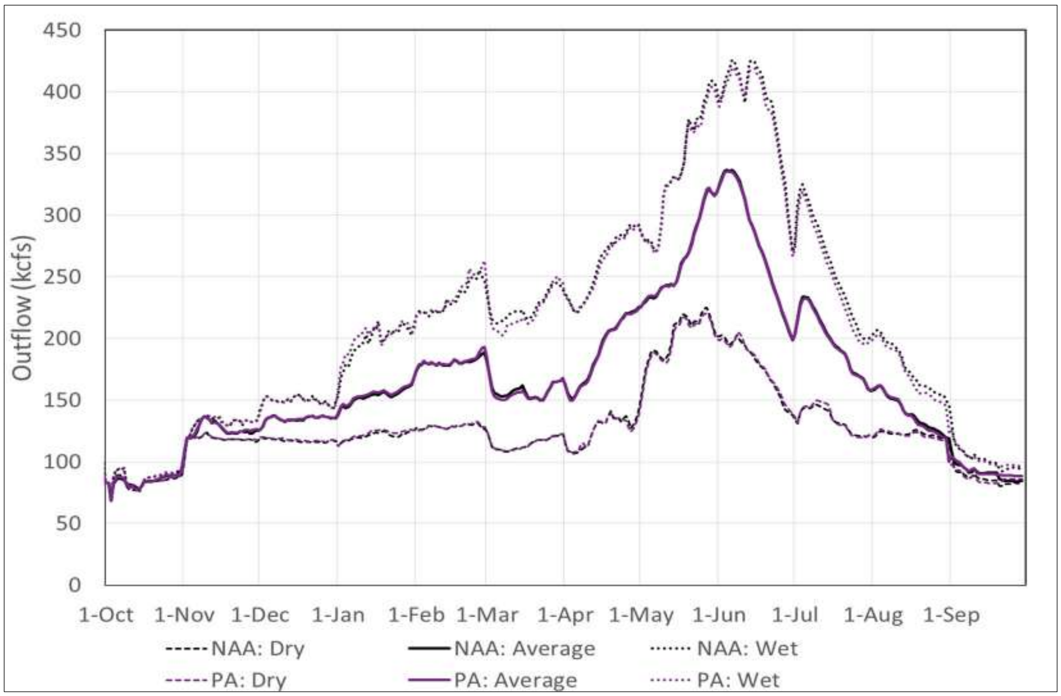

Figure 2.2-9. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

Juvenile SR spring/summer Chinook salmon migrate through the lower Snake and Columbia Rivers primarily in April and May, and the Action Agencies will operate to meet seasonal flow objectives to support juvenile migrants during that period. Adult SR spring/summer Chinook salmon migrate primarily in April to August. The proposed change in flow would be too small to affect river temperature during the adult migration period, which would be the attribute of highest concern. The associated effects on SR spring/summer Chinook smolts or adults should not change from recent conditions by a meaningful amount.

The effects of the proposed hydrosystem operations and the non-operational measures on SR spring/summer Chinook salmon and its habitat are described below.

2.2.3.1.2 Water Quality

The operation of the CRS will continue to affect water quality parameters in the mainstem migration corridor. This includes delayed spring warming, delayed fall cooling, reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs, and the continued releases of cool water from storage at Dworshak Dam to moderate lower Snake River water temperatures from June through September.

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacity spill. These events occur most frequently in May and June but may also occur other months.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spill operation would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. Individuals from all populations and MPGs would be exposed similarly. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020). Data from all fish sampled in the CRS Gas Bubble Trauma Monitoring Program (1996 to 2019) indicate that signs of GBT were almost non-existent below 120 percent TDG, increased slightly between 121 percent and 125 percent TDG, and then increased in incidence and severity when TDG levels exceeded 125 percent (FPC 2019). The available information in Zabel (2019) and Widener et al. (2020) suggests that the relatively high TDG exposure often exceeding 125 percent during high flow years (e.g., 2006 and 2011) did not reduce smolt survival through the CRS. Thus, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (likely not measurable based on reach survival studies) increase in mortality of juvenile SR spring/summer Chinook salmon.

Adult SR spring/summer Chinook salmon typically migrate between Bonneville and Lower Granite Dam during the period that the flexible spill operation would occur (April through June). Adults also migrate at depths that reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[68] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on SR spring/summer Chinook salmon are likely to be very small and are not expected to detectably affect reach survival estimates.

Sediment Transport

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency hypothetically increases the exposure of SR

[68] The Corps provides oil accountability reports for public review at: https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

spring/summer Chinook salmon juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile SR spring/summer Chinook salmon typically spend days to weeks in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

2.2.3.1.3 Project Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems (BPA et al. 2020). Maintenance activities evaluated and covered under this opinion can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance, as summarized in Section 1.3 of this opinion and in further detail in BPA et al. (2020).

Fishway structures (e.g., fish ladders, screens, bypass systems) will be routinely maintained and temporarily removed from service on a scheduled basis during the established in-water work period (December to March), in accordance with the Fish Passage Plan and coordinated through FPOM to minimize impacts to adult and juvenile migrants. At Bonneville Dam, routine dredging in the forebay and rock removal in the spillway will occur every year or two to ensure reliable operation and structural integrity of the fishways. Turbine unit maintenance is planned at all dams and will be coordinated through FPOM to minimize and avoid delay, injury, and mortality.

Routine outages of fishways are necessary to maintain reliability, but these temporary outages can cause delay and mortality for adult and juvenile migrants that attempt to migrate at the time of the outage. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be very few, or relatively low numbers of, SR spring/summer Chinook salmon that are migrating, and these effects will occur at extremely low levels similar to what was observed in the recent past. Passage delay and conversion rates will be monitored and maintenance schedules may be modified through FPOM or adaptive management if evidence indicates elevated delay and mortality are occurring.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization and major rehabilitations. Non-routine maintenance expected in the timeframe of the proposed action includes the installation of improved fish passage (IFP) turbines at three out of six turbine units at Ice Harbor Dam. At McNary Dam, turbine replacement is expected to begin within the next 15 years. At John Day Dam, turbine replacement may begin, but it is uncertain at this time if it will be completed, within the 15-year period of the proposed action. The proposed maintenance at Grand Coulee could result in outages and additional spill in limited situations, but changes to total outflows are not expected. The Corps will repair the existing jetty and retaining wall located near the north shore adult ladder entrance at Little Goose Dam, where significant erosion has occurred. Replacing the jetty with large rock and/or large coffer cells will restore passage conditions to pre-2011 levels at the north shore ladder entrance when spill exceeds 30 percent at Little Goose Dam. Non-routine maintenance (related to turbines or spillbays) expected in the proposed action can increase TDG during uncontrolled spill by temporarily reducing powerhouse capacity and may cause suboptimal tailrace conditions which can delay passage. The installation of IFP turbines will likely improve turbine survival and reliability once completed. Repairing the jetty at Little Goose Dam will likely reduce delay for adults and improve passage conditions when spill exceeds 30 percent. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce risk to adults and juveniles.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated with NMFS and through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize negative effects on fish. Fish passage metrics will be monitored with counts and PIT tags to ensure unscheduled maintenance activities do not result in negative impacts to the ESU.

Overall, scheduled maintenance activities are expected to continue to negatively affect only small numbers of adult and juvenile SR spring/summer Chinook salmon annually because very few are migrating during the period of time when these activities are typically scheduled. The impact of unscheduled maintenance on juvenile and adult SR spring/summer Chinook salmon will likely continue to result in increased TDG exposure, passage delay, and occasional mortalities during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes will continue to minimize the impacts.

2.2.3.1.4 Adult Migration/Survival

Adult survival rates for SR spring/summer Chinook salmon are expected to continue to average about 89 percent (2010 to 2019 average) from Bonneville Dam to McNary Dam and 83 percent from Bonneville Dam to Lower Granite Dam. Based on modeling and physical observations, the tailrace conditions at John Day, Lower Monumental, Little Goose, and Lower Granite Dams are likely to be degraded by the increased gas-cap spill levels (typically 16 hours per day) resulting from the flexible spill operation during the spring spill period. Changes in the ability of adults to locate and utilize fishways are not anticipated for SR spring/summer Chinook salmon at the other lower Columbia and Snake River dams. The spring spill operation is likely to increase travel times for adult SR spring/summer Chinook salmon by reducing their ability to rapidly find fishway entrances at some dams. During controlled spill conditions, the 8 hours of performance level spill should be sufficient to prevent measurable impacts to adult survival under most conditions. However, an observed increase in travel times and reascension rates of adult SR spring/summer Chinook at some Snake River projects (e.g., Lower Monumental and Little Goose Dams) during the 2020 spring passage season suggests that further refinement of 125 percent gas cap and performance spill operations through the adaptive management process may be needed in future years. Following this process, it may be necessary to adjust performance spill duration or timing at some projects if negative impacts to adult SR spring/summer Chinook are observed.

Fallback rates—which are associated at many dams with higher spill levels—may increase slightly at the mainstem dams (except The Dalles Dam). Adult fallback has been associated with longer migration times and reduced survival rates. Increased spring spill levels are expected to slightly increase adult fallback rates. Not all individuals that fall back will successfully reascend the fishways, and those that do will experience delay. However, the potential for loss will be reduced by the fact that, at the higher spill levels, more of these adults will have fallen back through spillbays, which would reduce injury and mortality rates relative to fallback through juvenile bypass systems or turbine units. Managers can use data on fallback and reascension rates to identify excessive fallback or migration delays and implement remedies through adaptive management processes.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. This change would affect very small numbers of adult SR spring/summer Chinook salmon that will still be migrating after that date in August by improving adult ladder attraction conditions and reducing fallback rates of SR spring/summer Chinook. However, individuals that fall back will experience greater risk because they would be more likely to pass via turbines and juvenile bypass systems instead of the spillway.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14, unless adjusted due to (rare) low flow occurrences in the Snake River to meet authorized project purposes. Maintaining the increased operating range by 6 inches at the lower Snake River dams (MOP 1.5-foot range) as implemented in 2019 and 2020 has not yet been fully evaluated under a range of flow years. The increase in operation range is expected to slightly reduce the average flow rate in the reservoirs, but the flow change is minimal and is not expected to affect adult migration timing or survival rates.

The Action Agencies propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of minimum irrigation pool (MIP) (262.5 to 264.5 feet), except during the spring spill period, when the John Day forebay operating elevation window will be increased. From April 10 to June 1 to 15, the elevation of John Day Reservoir will be held between 264.5 feet and 266.5 feet to deter piscivorous Caspian terns from nesting in the Blalock Islands Complex (see

Section 2.2.3.1.10). Following this operation, John Day Reservoir elevation would return to MIP + 2 feet operation through August 31. The increase in operating range is expected to slightly reduce velocities in John Day Reservoir, but the velocity change is not expected to affect adult migration timing or survival rates.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. PIT-tag data indicate that adult SR spring/summer Chinook salmon have migrated through the Snake River prior to this operation beginning, so we expect there will be no effect on adult migration timing or survival for this ESU.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for adult salmonids passing through the turbine units, but the number of adults affected should be extremely low because of the limited time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure and improve ladder attraction conditions for adult SR spring/summer Chinook salmon, but would also slightly reduce turbine unit survival for adult salmonids passing through the turbine units. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams from April through June. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. Due to the low frequency that this operation is expected to occur, overall adult survival rates of SR spring/summer Chinook salmon between Bonneville Dam and Lower Granite Dam should not be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

2.2.3.1.5 Juvenile Migration/Survival

The Action Agencies propose to continue to provide fish passage spill (conventional and surface passage), operate juvenile bypass systems, and implement other operations (e.g., ice and trash sluiceways, Bonneville corner collector, etc.) for juvenile passage at the eight lower Snake and lower Columbia River dams. Surface passage structures and juvenile bypass systems exist at all four of the lower Snake River dams, and surface passage structures exist at each of the four lower Columbia dams, and three of them have juvenile bypass systems. The Dalles Dam does not have a juvenile bypass system because of low powerhouse passage rates. Increased spill levels resulting from the flexible spring spill operations are expected to have little negative effect on tailrace conditions at Bonneville, The Dalles, McNary, and Ice Harbor Dams, but could cause eddies to form at other dams under low to moderate flow conditions. The latter would likely increase the exposure to predators of juvenile Chinook salmon passing through the spillway, thereby reducing spillway survival by a small, but unknown, amount. Increased spill levels at the other dams (excepting The Dalles Dam which will continue spilling at 40 percent) would generally be expected to slightly increase direct dam passage survival rates of inriver migrating smolts as spillway survival rates generally exceed those in the juvenile bypass systems or through the turbine unites. Overall, the survival of inriver migrating juvenile SR spring/summer Chinook salmon from all populations and MPGs should increase slightly as a result of implementing the flexible spring spill levels at each of the eight mainstem dams. Increases in downstream migration survival are expected to increase population productivity by delivering more smolts to the ocean, resulting in more adults returning.

The proposed operations at Libby Dam, Hungry Horse Dam, Grand Coulee Dam, and Dworshak Dam will alter flows by less than 2 percent during the spring migration period. This would be expected to result in very small increases in travel times in April and May, and small decreases in travel times in June, but should not measurably affect juvenile survival. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. Because SR spring/summer Chinook salmon juveniles migrate during the spring, they will not be affected by a reduction in summer spill in late August.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14. Maintaining the increase in the operating range by 6 inches at the lower Snake River dams (MOP 1.5-foot range), as implemented in 2019 and 2020, has not yet been fully evaluated under a range of flow years. Mean travel time from Lower Granite Dam to Bonneville Dam was faster in 2019 than the previous average for SR spring summer Chinook salmon (Zabel 2019, Widener et al. 2020), but may be attributed to a high flow year. The increase in operating range by itself is expected to slightly reduce the average flow rate in the reservoirs and slightly increase travel time for juvenile SR spring/summer Chinook salmon compared to the recent average. By itself, an increase in travel time would be expected to reduce smolt to adult return rates, however, based on COMPASS modeling, we expect the proposed action as a whole with an increase in spill will result in a reduction in total average travel times.

The Action Agencies also propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP level (262.5 to 264.5 feet), except during the spring spill period when the John Day forebay operating range will be increased. From April 10 to June 1 to 15, the elevation of John Day Reservoir will be held between 264.5 feet and 266.5 feet to deter Caspian terns from nesting in the Blalock Islands Complex (Section 2.2.3.1.10). Following this operation, the elevation of John Day Reservoir would return to MIP + 2 feet operation through August 31. The increase in operation range is expected to reduce the flow rate in John Day Reservoir, increasing travel time for juvenile SR spring/summer Chinook salmon compared to the recent average. By itself, an increase in travel time would be expected to reduce smolt to adult return rates, however, based on COMPASS modeling, we expect the proposed action as a whole with an increase in spill will result in a reduction in total average travel times.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. Few to no juvenile SR spring/summer Chinook salmon are expected to migrate through the lower Snake River during this period, so this operation will have extremely minimal to no effect on juvenile migration timing or survival.

As described above (see Section 2.2.3.1.5), under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, but the number of juveniles affected should be extremely low.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure, would slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, and would slightly increase powerhouse passage rates of juvenile SR spring/summer Chinook salmon. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units and increase powerhouse passage rates.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams from April through June. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of SR spring/summer Chinook between Bonneville Dam and Lower Granite Dam, given the relatively short duration (and magnitude) of the exceedances and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

COMPASS Model Results

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT-tags (detection efficiencies and project and reach survival estimates) and acoustic tags (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model.

For SR spring/summer Chinook salmon, COMPASS estimates that under the proposed flexible spring spill operation (up to 125 percent TDG) and increased pool elevations at the Snake River projects and John Day Dam:

- Average juvenile travel time from the Lower Granite tailrace to the Bonneville Dam tailrace is 16.7 days.
- Average juvenile survival from the head of Lower Granite Reservoir to the Bonneville Dam tailrace is 50 percent.
- Average proportion of juveniles approaching Lower Granite Dam that are destined for transport is 25.4 percent.
- Average number of spill passage events (the inverse of the CSS's PITPH metric) is 6.9 for the eight dams traversed (Lower Granite to Bonneville Dam).

The CSS hypothesizes that flexible spring spill would reduce latent mortality by reducing the number of powerhouse encounters. The CSS estimates that the 125 percent TDG Flexible Spill Operation will increase adult returns (SARs) by 35 percent. If this proves to be true, an additional improvement in adult returns may occur. However, another possible explanation for reduced return probabilities of bypassed fish is that smaller fish and those in poorer condition tend to enter bypass systems with higher probability than fish that are larger or in better condition (Zabel et al. 2005, ISAB 2012, Hostetter et al. 2015, Faulkner et al. 2019), and smaller fish and fish in poorer condition also have lower return probability (Ward and Slaney 1988, Zabel and Williams 2002, Evans et al. 2014). This suggests that the apparent effects of juvenile bypasses on juvenile survival and adult return probability are due, at least in part, to the correlation between bypass probability and fish size and condition, and not due to bypass passage itself. Thus, increasing spill levels will incrementally increase the proportion of spillway passed fish and reduce travel times, and could improve direct juvenile survival rates, assuming spillway passage survival rates are not substantially reduced as a result of poor egress and tailrace conditions. However, increasing spill levels might not increase adult returns to the extent hypothesized by the CSS. Since higher spill levels can result in degraded tailrace conditions, juvenile survival could be lower than COMPASS predicts as a result of extended tailrace delay and the potential for predation at some projects.

These COMPASS estimates of survival rates and travel times do not estimate the magnitude of effects solely attributable to the operation of the CRS projects. We expect that some of the mortality and delay in travel times is attributable to the existence of the eight mainstem dams as opposed to operational or configurational choices. In addition, some sources of mortality, such as predation, are captured in the COMPASS estimates but would exist at some level regardless of the proposed action. The mortality of about half the juvenile SR spring/summer Chinook salmon from Lower Granite Reservoir to Bonneville Dam estimated from the models is therefore due to a combination of these factors. Accordingly, we view the effects of the hydrosystem action on juvenile mortality and travel times as being less than the COMPASS estimates, but to an unknown degree.

2.2.3.1.6 Transportation

SR spring/summer Chinook salmon smolts will continue to be collected for transport at the three Snake River collector projects. On average, the increased spill will result in more juvenile fish going over the spillway and fewer fish being transported on a given date. This effect will be especially pronounced in low to medium flow years. Should TIR ratios continue to demonstrate an overall benefit of transport to SR spring/summer Chinook SARs, the expected decrease in transport rates resulting from increased spill at the three collector projects would, on average, result in a reduction in adult returns. However, recent CSS modeling predicts TIR ratios will not show a benefit for transport with increased spill due to a large increase in adult returns for fish migrating in the river (CSS 2019).

The decrease in the daily proportion of fish collected due to higher spill would be countered by an increase in the proportion of the juvenile run that is collected if transport is started earlier. SR spring/summer Chinook salmon smolts begin arriving at Lower Granite Dam in early April. Enacting a start date of April 23 to 24, as was done in 2018 and 2019, results in higher numbers of natural-origin and hatchery spring/summer Chinook salmon smolts transported. The Action Agencies propose a target start date for transportation of April 24, but also propose that the start date may be adaptively managed to begin as early as April 15, or as late as May 1. Transport was started on April 24 in 2019 and 2020, which will provide new data to inform an analysis of the benefit of transport in late April. If monitoring demonstrates a survival benefit for early migrating juveniles transported from April 24 to May 1, the Action Agencies have proposed beginning transport even earlier, as early as April 15 if data suggests this would improve adult return rates. From 2010 to 2019, an average of 50 percent of yearling Chinook salmon had arrived at Lower Granite Dam by April 15, and so an April 15 start date would substantially increase the proportion of smolts that are transported (and decrease the proportion of fish bypassed back to the river), which could improve overall juvenile survival and adult return rates. In the future, SR spring/summer Chinook salmon smolts may outmigrate even earlier in response to climate change, and in this case adaptively managing to start transport earlier could similarly improve juvenile survival and adult return rates.

The proposed cessation of transport from June 21 up to August 15 will reduce the collection and transportation of the latest-migrating SR spring/summer Chinook salmon smolts. From 2010 to 2019, on average, 95 percent of yearling Chinook salmon had arrived at Lower Granite Dam by May 17, but a few smolts continued to migrate in the Lower Snake River in June and July. These late-migrating smolts generally benefit from transport. However, juvenile Snake River spring/summer Chinook salmon numbers are so few that the effect of stopping transport from June 21 up to August 15 would be minimal for SR spring/summer Chinook salmon. The decision on when to stop and then restart juvenile fish transport would remain subject to the TMT and FPOM decision processes and the dates could be changed, for example if smolt outmigration timing shifts later in a given year and ceasing transport on June 21 is determined to be detrimental.

2.2.3.1.7 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to SR spring/summer Chinook salmon as they migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty about predicting the availability of habitat restoration actions into the future and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about the potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and will be initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the action effectiveness monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program either will confirm that these floodplain reconnections are enhancing conditions for yearling salmonids such as SR spring/summer Chinook salmon as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change considerations and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management, which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the influx of insect and amphipod prey to the mainstem migration corridor for SR spring/summer Chinook salmon. It is also reasonably certain that these benefits will increase as habitat quality matures, contributing to increased abundance, productivity, and life-history diversity[69] of all SR spring/summer salmon populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.2.3.1.8 Tributary Habitat

For the SR spring/summer Chinook salmon ESU, the Action Agencies will implement tributary habitat improvements to achieve the MPG-level metrics outlined in Table 2.2-17. These habitat improvement actions will be implemented in three of the five MPGs: Grande Ronde/Imnaha, Upper Salmon River, and Lower Snake River.[70] Actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations, and will accomplish specific metrics defined for each MPG (BPA et al. 2020).

Table 2.2-17. Proposed tributary habitat metrics (2021 to 2036) for major population groups in the SR Spring/Summer Chinook Salmon ESU (BPA et al. 2020).

Major Population Group	Snake River Spring/Summer Chinook Salmon ESU Metrics[1]					
	Flow Protected (cfs)	**Flow Enhanced (acre-feet)**	**Entrainment Screening (# screens)**	**Habitat Access (miles)**	**Stream Complexity (miles)**	**Riparian Habitat Improved (acres)**
Grande Ronde/Imnaha	178	15,509	0	87	24	420
Upper Salmon River	171	21,779	36	30	18	107
Lower Snake	0	0	0	6	29	468
ESU Totals	349	37,288	36	123	71	995

[1] The habitat actions that produce these metrics will be completed, or in process, by the end of 2036.

To develop these metrics, the Action Agencies reviewed implementation under the 2008 and 2019 biological opinions and developed metrics for the proposed action assuming a consistent level of effort for tributary habitat implementation. In addition, the Action Agencies have committed to continuing to improve the strategic implementation of the program; to continue implementing the program with input from the Tributary Habitat Steering Committee (THSC) that was convened under the 2019 biological opinion; to convene a Tributary Technical Team (TTT) to provide input to program implementation; to report on implementation using metrics

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[69] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile Chinook salmon opportunities to move into wetland habitats for food and refuge from predators. Moreover the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the SR spring/summer Chinook salmon ESU.

[70] The focus on implementation in these three MPGs is generally consistent with past implementation of the Action Agencies' tributary habitat program.

that will allow NMFS to evaluate implementation of the program; to undertake comprehensive program reviews every 5 years to evaluate how to enhance benefits from the program; and to conduct RME to assess tributary habitat conditions, limiting factors, and action effectiveness, and to inform our understanding of critical uncertainties (BPA et al. 2020).

As part of the adaptive management program, the Action Agencies, with input from the THSC and TTT, will reevaluate implementation at 5-year intervals (see Appendix D of BPA et al. 2020). The proposed metrics after the first 5-year period may be adaptively managed, based on input from the THSC and TTT, to optimize fish benefits based on understanding of species status and population priorities, limiting factors, what actions will provide the greatest benefits, implementation considerations, etc.

For an overview of how NMFS analyzed the effects of tributary habitat improvement actions for this opinion, see Appendix A. In brief, we reviewed and re-affirmed the strong technical foundation for the tributary habitat program (i.e., that strategically implementing actions to alleviate the factors that limit the function of tributary habitat will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead). We evaluated new RME information and found that it also supported the foundation of the program. We determined that the methods we were using to evaluate the effects of tributary habitat actions were based on best available science, as described in Appendix A. We evaluated the effects of those actions quantitatively for some populations and qualitatively for all populations within the context of our understanding of limiting factors, the effects of the types of habitat improvement actions being proposed, population extinction risk, habitat improvement potential, ESA recovery plan goals, and our focus population framework. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered certainty of implementation and effects, as well as the strategic framework within which the Action Agencies were committing to implement the program. In addition, we considered the adequacy of the RME and adaptive management framework that is proposed to guide and refine implementation of the habitat improvement actions and inform our understanding of their effects, and the adequacy of the proposed reporting on actions implemented.

Our assessments are described below by MPG, followed by an ESU-level summary.

South Fork Salmon River MPG

The Action Agencies have not proposed tributary habitat improvement actions for implementation in this MPG as part of the proposed action.

Middle Fork Salmon River MPG

The Action Agencies have not proposed tributary habitat improvement actions for implementation in this MPG as part of the proposed action.

Upper Salmon River MPG

For the Upper Salmon River MPG, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, reduce entrainment by screening water diversions, improve habitat access, improve stream complexity, and improve riparian habitat. Limiting factors in this MPG include reduced flows, loss of habitat complexity, reduced riparian function, passage barriers, and entrainment of juvenile and adult fish in irrigation facilities (see Section 2.2.2.4), so these actions would be targeted toward addressing identified limiting factors.

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.2-18. The positive changes noted in the table may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

Table 2.2-18. Effects and timing of effects of proposed tributary habitat improvement actions for SR spring/summer Chinook salmon.

Action Type	Effects of action and timing of effects
Flow protection and enhancement	Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017a). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Sabaton et al. 2008, Roni et al. 2014). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and the success of these projects (Roni et al. 2008). For example, ongoing studies in the Lemhi River show increased spawner and juvenile abundance of both Chinook salmon and steelhead following enhancement of instream flows in tributaries (Uthe et al. 2017, Appendix A of Griswold and Phillips 2018). The effects of flow augmentation on habitat conditions depend on the amount of flow within the channel and how much water is added. Augmented flow in dewatered channels or streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).
Improved habitat access	Impaired fish passage can prevent adults from accessing upstream spawning habitat and impede juvenile fish migration. In addition, structures that impede fish passage can disrupt habitat-forming processes related to flow, sediment transport, and large wood (NMFS

Action Type	Effects of action and timing of effects
	2013a, 2017a). Improving fish passage through actions that replace, improve, or remove culverts, dams, and other migration barriers, or that provide fish passage structures, can provide access to previously inaccessible spawning and rearing habitat. In addition, removing barriers can enhance habitat-forming processes related to flow, sediment transport, and movement of large wood and contribute to improvements in stream morphology, substrate, connectivity, stream flow, and stream temperature (NMFS 2013a, Hillman et al. 2016). Studies evaluating the effectiveness of projects that have removed impassable culverts/dams or have installed fish passage structures in North America and elsewhere, including in the Columbia River basin, have consistently shown rapid colonization by fishes; some studies have also documented the physical impacts of barrier removal on sediment and channel changes (Hillman et al. 2016). The rate at which salmon and trout recolonize habitats following barrier removal is highly dependent on the amount and quality of habitat upstream of the barrier, and the size of the downstream or nearby source population (number of salmon or trout returning that could colonize) (Hillman et al. 2016).
Improved stream complexity	Stream complexity created by large wood, boulders, coarse substrate, undercut banks, and overhanging vegetation (in concert with adequate flow regimes and other habitat-forming processes) is an essential feature of productive salmon habitat, providing the features needed for adequate spawning and rearing. Functioning floodplains and side-channels with hydrologic connectivity are also key features of productive salmon habitat because they provide rearing, resting, and refuge habitat; increase availability of prey; and enhance other stream and watershed processes (NMFS 2013a, 2017a). Habitat improvement actions commonly implemented to enhance stream complexity include placement of large wood, boulders, and cover structures; gravel addition; floodplain reconnection; side channel and pond construction and reconnection; levee removal and setback; channel re-meandering; and, more recently, the construction of beaver enhancement structures (Roni et al. 2014, Hillman et al. 2016). These actions can be expected to aid in reestablishment of hydrologic regimes, increase availability of rearing habitat, improve access to rearing habitat, increase the hydrologic capacity of side channels, increase channel diversity and complexity, provide resting areas for salmonids, provide flood water attenuation, and enhance native plant communities (NMFS 2013a). The placement of instream structures includes a wide variety of actions that can affect many different habitat factors, so salmonid responses documented in the literature are quite diverse, ranging from small negative responses to large increases in abundance, growth, and survival. Most studies of this type of action indicate a positive response (increased abundance and density) for salmonids. The lack of response or decrease in abundance identified in some studies was often because the projects did not address upstream watershed processes (e.g., sediment, water quality, etc.), the actions did not address the factors limiting fish, the duration of monitoring was too short to demonstrate a positive effect, or the treatments resulted in little change in physical habitat. Salmonids have also been shown to respond rapidly to reconnected or constructed floodplains, side channels, and wetlands. These habitats provide critical rearing habitat for juvenile Chinook, coho, and steelhead. Studies indicate that these actions increase salmonid abundance, individual growth rates, overwinter survival, and smolt production (Hillman et al. 2016). While benefits of actions to improve stream complexity may be rapid in terms of fish occupying restored habitats, they also will continue to accrue over some time as habitat continues to respond.
Riparian Habitat Improvement	Riparian vegetation provides numerous functions including shading, stabilizing streambanks, controlling sediments, contributing large wood, and regulating the flow of nutrients. Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014, Hillman et al. 2016, NMFS 2017a). Benefits of riparian planting actions take more than 50 years to fully accrue, although some

Action Type	Effects of action and timing of effects
	benefits begin to accrue after 5 to 10 years (Justice et al. 2017, Pess and Jordan eds., 2019). Few studies have examined the response of instream habitat or fish to riparian planting or thinning, in part because of the long lag time between tree growth and any change in channel conditions or delivery of large wood. However, a retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and instream anadromous fish habitat at revegetated sites. Modeling work in the Grande Ronde River indicates that riparian enhancement action should reduce water temperatures and increase juvenile salmonid abundance up to 377 percent in the Upper Grande Ronde River subbasin and 61 percent in Catherine Creek (McCullough et al. 2016). Justice et al. (2017) utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River subbasin and Catherine Creek Basins in Oregon. They focused on streams that had been degraded by intensive land use leading to reduced riparian vegetation and widened channels and concluded that restoration of such streams could more than make up for expected increase in summer stream temperature through 2080. Studies of fish response to livestock exclusion projects have shown variable results. Some have shown increases in salmonid abundance while others have shown no response. Those showing no response were linked to short duration of monitoring, small size of enclosures, and upstream habitat processes that limited habitat conditions in the project area (Hillman et al. 2016).
Entrainment	Diversion of water from rivers can negatively affect salmon and steelhead populations. For example, open, unmodified water diversions can act as a source of injury or mortality to resident or migratory fishes from entrainment and impingement, and can cause habitat degradation and fragmentation. Fish-protection devices, such as exclusion screens, can physically or behaviorally deter fish from approaching or being entrained into water diversions. Most monitoring of screening projects is compliance monitoring rather than effectiveness monitoring, with a focus on whether installation or upgrading screens has reduced entrainment of fish into irrigation or water withdrawal systems. In one evaluation, however, Walters et al. (2012) conducted modeling that indicated that an extensive program to install screens at irrigation diversions in the Lemhi River had potentially significantly reduced mortality of out-migrating Chinook salmon smolts. Screening irrigation or water withdrawal systems and reconnecting spawning and rearing streams often provide immediate and important survival and carrying capacity benefits (Hillman et al. 2016).

There is generally high potential for improvement in habitat productivity in all populations in this MPG. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced (Appendix A; also see Hillman et al. 2016, Pess and Jordan eds. 2019).[71]

[71] Ultimately, implementation should be focused on where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. The Action Agencies indicated (BPA et al. 2020) that during the first 5-years of the proposed action they would likely focus implementation of tributary habitat actions on the populations identified as priority populations in the 2008

The Action Agencies have well-developed partnerships with local implementing groups in this MPG. Implementation of habitat actions within this MPG occurs primarily through the Upper Salmon Basin Watershed Program, which includes staff from state, Federal, and local natural resource management agencies; more than 75 ranchers in the upper Salmon River basin; private interest groups; and others. This group has created an effective process for working together, providing technical reviews of proposed projects, and working with interested parties to accomplish conservation on the ground. It has a strong record of implementing projects that have made contributions to salmon recovery (NMFS 2017d). In collaboration with these local partners, the Action Agencies have used a variety of tools, including the Screening and Habitat Improvement Prioritization for the Upper Salmon Subbasin, and the Integrated Rehabilitation Assessment (Idaho OSC IRA Team 2019) to prioritize and select projects. This team has also relied on guiding documents and information such as the recovery plan (NMFS 2017a), tributary assessments, and additional technical analysis to sequence actions and areas to implement habitat actions in priority watersheds within this MPG. This on-the-ground infrastructure, combined with the Action Agencies' commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

To help assess the extent of benefits, NMFS used a life-cycle model to evaluate the effects of some types of the proposed tributary actions on populations in this MPG (see Section 2.2.3.1.12). The proposed tributary habitat actions for 2021 to 2036 for this MPG include flow protection and enhancement, screening of diversions, access, stream complexity, and riparian habitat improvement. The model, however, can only assess the benefits to juvenile rearing and adult spawning capacity of instream actions to improve stream complexity or floodplain/side-channel connectivity and actions to improve access. Because the model does not evaluate the effects of actions such as returning flow to the stream, screening diversions, and restoring riparian areas, benefits of those types of actions are not included in the model results. For the analysis, modelers assumed that the Action Agencies' efforts would be focused on the Lemhi, Pahsimeroi, and Upper Mainstem populations. Modelers also made other assumptions, documented in Pess and Jordan, eds. (2019) (e.g., habitat access projects were assumed to open habitat of similar type and quality to that currently available, and complexity actions were applied to improve the quality of habitat currently in moderate or good condition).

Based on model results, the proposed actions would increase juvenile rearing capacity by 12.3 percent in the Lemhi, 19.8 percent in the Pahsimeroi, and 10.5 percent in the Upper Mainstem;

biological opinion—in this MPG, the Lemhi, Pahsimeroi, Upper Mainstem Salmon River, Valley Creek, and Yankee Fork populations. The Lemhi, Pahsimeroi, Valley Creek, East Fork Salmon River, and Upper Mainstem Salmon River populations are targeted for viable or highly viable status in the ESA recovery plan for SR spring/summer Chinook salmon (NMFS 2017a). Ultimately, the Yankee Fork population will also need to improve to "maintained" status to meet ESA recovery criteria (NMFS 2017a). NMFS' focal population analysis identified the Pahsimeroi, Lemhi, and East Fork Upper Salmon River populations as having the highest potential to benefit MPG status in the near term from directed habitat actions (Cooney et al. 2020a). NMFS will work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent that they are not currently aligned.

spawning capacity would increase by 7.8 percent in the Lemhi, 19.8 percent in the Pahsimeroi, and 6.9 percent in the Upper Mainstem. Changes in abundance of natural-origin spawners and extinction risk for this population as a result of these actions are captured in the life-cycle modeling results discussed in Section 2.2.3.1.12. Because the model does not evaluate the effects of actions such as returning flow to the stream, screening diversions, and restoring riparian areas, benefits of those types of actions are not included in the modeled increases in capacity. Further, the modeling may not have captured all benefits attributable to the specific actions that were evaluated. Modeling methods, assumptions, and results are documented in detail in Pess and Jordan, eds. (2019) and Jordan et al. (2020).

Grande Ronde/Imnaha MPG

For the Grande Ronde/Imnaha MPG, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, improve habitat access, improve stream complexity, and improve riparian habitat. Limiting factors in this MPG include reduced flows, loss of habitat complexity, reduced riparian function, and passage barriers (see Section 2.2.2.4). The actions would be targeted toward addressing these identified limiting factors.

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.2-19. The positive changes noted in the table may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

There is high potential for improvement in habitat productivity in most populations in this MPG. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016, ISAB 2018, Pess and Jordan eds. 2019).[72]

The Action Agencies have well-developed partnerships with local implementing groups in this area. To help guide restoration priorities in the severely degraded Catherine Creek and Grande Ronde subbasins, the Action Agencies have worked with local partners since 2011 to develop, implement, and adaptively manage the Atlas process (described above in Section 2.2.2.4), a systematic approach to identify and prioritize the actions that would be most likely to improve habitat. The Atlas framework has resulted in implementation of habitat improvement actions that target high-priority reaches for the Upper Grande Ronde River and Catherine Creek populations (NMFS 2014a, BPA et al. 2016). This on-the-ground infrastructure, combined with the Action Agencies' commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

To help assess the extent of benefits, NMFS used a life-cycle model to evaluate the effects of some types of the proposed tributary actions on populations in this MPG (see Section 2.2.3.1.12). The tributary habitat actions proposed for 2021 to 2036 for this MPG and evaluated in the model include flow protection and enhancement, access, stream complexity, and riparian habitat improvement. For the analysis, modelers assumed that the Action Agencies' efforts would be focused on the Upper Grande Ronde River and Catherine Creek populations. Modelers also made other assumptions, documented in Pess and Jordan, eds. (2019) and in Cooney et al. 2020b (e.g., habitat access projects were assumed to open habitat of similar type and quality to that currently available, and complexity actions were applied to improve the quality of habitat currently in moderate or good condition). The modeling may not have captured all benefits attributable to the specific actions that were evaluated.

The model results indicate that for the Catherine Creek population, the proposed action would increase summer-rearing capacity by 75 percent after full implementation (i.e., after 15 years), and for the Grande Ronde River, by 26 percent As benefits of actions implemented during this opinion continue to accrue, functional parr capacity would increase by a total of 100 percent in Catherine Creek and 33 percent in the upper Grande Ronde River at 24 years post-implementation (Cooney et al. 2020b, Pess and Jordan eds. 2019). Changes in abundance of

[72] Ultimately, implementation should be focused on where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. The Action Agencies indicated that during the first 5-years of the proposed action they would likely focus implementation of tributary habitat actions on the populations identified as priority populations in the 2008 biological opinion—the Grande Ronde, Catherine Creek, and Lostine/Wallowa populations. Based on NMFS' focal population analysis, addressing tributary habitat limiting factors in the Catherine Creek population has the highest potential to contribute to near-term MPG status improvements, followed by actions directed at limiting factors in the Lostine/Wallowa and Upper Grande Ronde populations (Cooney et al. 2020a). NMFS will work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent they are not currently aligned.

natural-origin spawners and extinction risk for this population as a result of these actions are captured in the life-cycle modeling results discussed in Section 2.6.3.1.13.

Lower Snake River MPG

For the Lower Snake River MPG, the Action Agencies have committed to continuing to implement actions to improve habitat access, improve stream complexity, and improve riparian habitat. Limiting factors in this MPG include loss of habitat complexity, reduced riparian function, and passage barriers (see Section 2.2.2.4), so these actions would be targeted toward addressing identified limiting factors.

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.2-19. The positive changes noted in the table may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

There is potential for additional improvement in habitat productivity in the Tucannon River population (the single extant population in this MPG). Actions implemented to ameliorate limiting factors for the single extant population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016, Pess and Jordan eds. 2019).

The Tucannon River population is the only extant population in this MPG, and for ESA recovery it must achieve highly viable status (NMFS 2017a). Thus, it is appropriate to focus near-term habitat improvement actions on this population.

The Action Agencies have well-developed partnerships in this area with local implementing partners, including the Snake River Salmon Recovery Board, the CTUIR, the U.S. Forest

Service, and the Washington Department of Fish and Wildlife (WDFW). A regional technical team, composed of fish biologists and other natural resource specialists with extensive field experience and knowledge of local watershed conditions, reviews actions before implementation (Appendix A of BPA et al. 2013). Specific reach-scale actions carried out under the Tucannon River Programmatic Habitat Project, funded by BPA, will be identified and prioritized based on detailed assessment information and taking into account key elements from the watershed restoration framework recommended by Beechie et al. 2010. Since 2012, the Action Agencies have used a geomorphic assessment to strengthen the technical understanding of physical conditions and geomorphic processes in the basin, and to identify and prioritize habitat improvement opportunities. This assessment characterized channel and floodplain conditions, channel confinement, the historical channel area, and the source, magnitude, and distribution of hydrologic and sediment inputs through the basin. This information was used to delineate reaches throughout the river that offer potential improvement opportunities. This on-the-ground infrastructure, combined with the Action Agencies commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that actions will be implemented strategically.

Summary of Effects to Tributary Habitat

In general, implementation of the tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will provide near-term and long-term benefits to the targeted populations by improving their tributary habitats in the manner and time frames outlined in Table 2.6-18, above. These benefits will accrue in three of the five MPGs in this ESU (the Upper Salmon, Grande Ronde/Imnaha, and Lower Snake River MPGs). For two of the five MPGs (the South Fork Salmon and the Middle Fork Salmon), the proposed tributary habitat actions will have no effect on the populations in the MPGs, because the Action Agencies have not proposed to implement any actions in those MPGs.

These improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations. In addition, certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change (Beechie et al. 2013, McCullough et al. 2016, Justice et al. 2017; also see Appendix A for additional discussion). Further, Crozier et al. (2019) looked at methods of increasing climate resilience for Pacific salmon and steelhead and concluded that reducing any anthropogenic stressor could improve response to climate change by improving the overall status of an ESU (in terms of abundance, productivity, spatial structure, and diversity) and thereby making the ESU more resilient and less vulnerable to stochastic extinction. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action.

2.2.3.1.9 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail in the site-specific biological opinions referenced therein (see Section 2.2.2.2). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.2.3.1.10 Predation Management

Avian Predators

Avian Predators in the Lower Columbia River Estuary

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions are likely to continue current levels of predation at these colonies, which, in the case of Caspian terns, is contributing to conditions that could increase the abundance and productivity of SR spring/summer Chinook salmon by a small amount compared to the pre-colony management period. However, ocean conditions, including compensatory effects such as the number and behavior of predators and competition for prey, will determine whether or not this reduction in tern predation influences adult returns. Although there also has been a small, but statistically credible, decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 4.6 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, cormorant predation in the estuary may be an increasingly important source of mortality for SR spring/summer Chinook salmon.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of new actions because none have been proposed at this time.

Avian Predators in the Hydrosystem Reach

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia and Snake River dams. At each dam, bird numbers will continue to be monitored, birds foraging in dam tailraces will be hazed (including, in some circumstances, lethal reinforcement), and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas and juvenile bypass outfall areas, will also continue. If proven biologically and cost effective, the Corps will deploy laser systems to haze birds foraging near bypass outfalls. Upgrades to existing systems, including bird wires at McNary Dam, will be coordinated through the FPOM and included in the annual Fish Passage Plans. We expect that these measures will continue to reduce predation on juvenile SR spring/summer Chinook salmon, although Zorich et al. (2012) were unable to quantify the amount of protection.

The Action Agencies propose to continue to address Caspian tern predation on lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015 but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. These measures are likely to preclude use of Crescent Island by Caspian terns. Reclamation will continue passive and active dissuasion efforts for Caspian terns on Goose Island. They have coordinated the timing and duration of the proposed work with USFWS to ensure it will be effective in maintaining the management objectives of fewer than 40 breeding pairs at this site, consistent with the IAPMP. This ongoing suite of colony management actions is likely to continue current levels of predation by terns in the interior Columbia River basin, which is a small improvement compared to the pre-colony management period.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the hydrosystem reach are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

John Day Reservoir—Spring Operations to Reduce Predation Rates by Caspian Terns

The Action Agencies propose to hold the elevation of John Day Reservoir at 264.5 to 266.5 feet from April 10 to June 1 or no later than June 15 each year, or as feasible based on river flows, to inundate bare sand habitat and deter Caspian terns from nesting in the Blalock Islands Complex. Because foraging effort and predation rates increase once chicks hatch, the Action Agencies will begin to increase the reservoir elevation before Caspian terns initiate nesting (i.e., operations may begin earlier than April 10). The Action Agencies will consider bird observations along with the run timing of juvenile steelhead to determine the dates each year. At the conclusion of this operation, the draft to operating range (262.5 to 264.5 feet) will be completed within 4 days. In general, 95 percent of the juvenile steelhead migration passes John Day Dam by June 1 (DART 2020m).

The timing of this operation is based on the expectation that Caspian terns will begin colonizing exposed habitat and start courtship and nest building within days to weeks of returning the reservoir to the 262.5 to 264.5-foot range. In general, chicks hatch about 27 days after eggs are laid, at which point energetic demands and fish consumption rates increase substantially. We expect that inundating bare sand habitat until after 95 percent of yearling steelhead pass John Day Dam will also reduce predation rates on individuals from the SR spring/summer Chinook salmon ESU.

Fish Predators

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. This fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the average number of Chinook salmon, including some SR spring-summer Chinook salmon, that will be handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy) will be no more than 100 adults (including jacks) and 200 juveniles per year. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams and will conduct test fisheries at additional dam projects on the Snake River as described in the proposed action (BPA et al. 2020). As the Dam Angling Program evolves and potentially expands, it may help to further reduce predation on juvenile SR spring-summer Chinook salmon. We estimate that no more than 10 adults (including jacks) and 20 juvenile Chinook salmon, including some from the SR spring/summer Chinook salmon ESU, will be caught in the Dam Angling Program per year.

These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including SR spring/Summer Chinook salmon.

Pinniped Predators

The proposed action does not include measures to address pinniped predation in the free-flowing lower Columbia River estuary downstream of the tailrace of Bonneville Dam.

To reduce the number of ESA-listed salmon and steelhead impacted by pinnipeds at fish ladder entrances at Bonneville and The Dalles Dams, the Action Agencies propose to continue to annually install (or leave installed year-round), and improve as needed, sea lion excluder devices at all adult fish ladder entrances at Bonneville Dam. The Corps will continue to annually fund dam-based hazing of pinnipeds observed in the vicinity of fish ladder entrances at Bonneville Dam. Hazing will generally be conducted from March 31 through May 31 and from August 15 through October 31. Hazing efforts will be focused on minimizing the amount of time that individual sea lions spend foraging near fish ladder entrances, but may also include dissuasion in haul-out areas at the dam (BPA et al. 2020).

The Corps will continue to provide the states and tribes with access to Bonneville Dam and the Bonneville Dam boat restricted zone, as appropriate, to support sea lion predation management. The Corps will provide support to fish and wildlife management personnel during sea lion dissuasion and/or removal operations. The Corps will fund dam-based hazing of pinnipeds observed in the vicinity of fish ladder entrances at The Dalles Dam on an ad hoc, as-needed basis. Since these measures are a continuation of what is currently implemented, we would expect future sea-lion consumption of SR spring/summer Chinook salmon in the Bonneville Dam tailrace to be similar to past rates, which averages 3.0 percent and ranges from 1.2 to 5.9 percent since the implementation of SLEDs and hazing in 2006 (Tidwell et al. 2020).

2.2.3.1.11 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult SR spring/summer Chinook salmon are likely to be present in shallow shoreline areas, an unknown portion of the ESU will continue to be stunned, harmed, or possibly even killed. At present, to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed, and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this ESU that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[73]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of SR spring/summer Chinook salmon will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS.
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - 83,400 hatchery and 50,000 natural-origin juveniles will be handled.
  - 1,600 hatchery and 750 natural-origin juveniles will die.
- Activities associated with all other RME programs.
  - 7,700 hatchery and 2,200 natural-origin adults will be handled.
  - 77 hatchery and 22 natural-origin adults will die.
  - 85,000 hatchery and 120,000 natural-origin juveniles will be handled.
  - 850 hatchery and 500 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program is expected to affect, on average, up to 21 percent of the natural-origin adult (recent, 5-year average) run (arriving at Lower Granite Dam) and up to 15.5 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to less than 1 percent of estimated ESU abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs

[73] Ongoing and future discussions are expected to lead to reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the effects of the RME programs on abundance are acceptable and warranted.

2.2.3.1.12 Life-Cycle Models

Life-cycle models were used to assess the likely effect of hydropower system operations in accordance with the proposed action, the future effect of habitat restoration actions (where they could be quantified), the effect of continuing hatchery production (in accordance with the most recent Hatchery Genetic Management Plans (HGMPs)), and the effect of recent, seasonally variable increases in sea lion predation (earlier migrating populations suffer higher mortality rates) in the lower Columbia River from the mouth to Bonneville Dam. The projected estimates of median geomean abundance of the modelled populations includes the effect of both positive (e.g., hydrosystem improvements, reduced harvest, pikeminnow and avian predator management actions, etc.) and negative (e.g., continuing negative effects of hydropower projects, land use practices, increased pinniped predation, etc.) factors which have affected the recruit-per-spawner estimates in the time series available for each population.

A time period of 24 years forward from 2020 was selected as a reasonable timeframe to assess parameters generated by the models, including the geomean spawner abundance and the Quasi Extinction Threshold (QET). The period of 24 years includes approximately 6 generations of fish that would have experienced the proposed action as juveniles and returned to their natal streams as adults.

The QET is an estimate of the probability of a population reaching abundance levels for four consecutive years which may be too small to effectively reproduce—especially in larger basins where spawning adults might have more difficulty finding one another. Small populations are also more at risk from demographic stochasticity, genetic processes, and environmental variability. Because the exact number at which this condition occurs for Chinook salmon populations is unknown (and is likely variable due to a number of factors), past biological opinions (e.g., NMFS 2008a) provided QET projections for 50, 30, 10, and 1 individual. In this opinion NMFS presents QET projections for 50 adults (for four consecutive years in the projected abundance estimates over the next 24 years) as a useful means of illustrating differences resulting from factors affecting the abundance and productivity of the modeled populations.

There were 20 populations modeled from the Upper Salmon, Middle Fork Salmon, South Fork Salmon and Grande Ronde MPGs. In the case of the Upper Salmon, two different models, one incorporating habitat actions, and another which only included the effects of temperature and flow were used for some of the same populations.

Life-cycle models are made up of components estimating juvenile downstream survival through the CRS and other dams (COMPASS model), ocean survival, adult upstream survival to the spawning grounds and the number of juvenile fish produced and their subsequent survival in the tributaries. Proposed tributary habitat actions were modeled as increases in habitat capacity and productivity, and proposed CRS operations were modeled using the COMPASS downstream survival model.

Both abundance and QET estimates include an alternative analysis with an estimated 35 percent increase in adult returns (productivity) due to reduced latent mortality effects from increased spill and reduced powerhouse passage (USACE et al. 2020). The CSS hypothesis proposes that fish that pass through bypass systems (powerhouse passage) suffer some effect that results in lower chances of returning as an adult. This hypothesis is based on observations that PIT tagged fish observed in bypass systems have lower chances of returning as adults (Budy et al. 2002, Petrosky and Schaller 2010, Buchanan et al. 2011, Haeseker et al. 2012, Schaller et al. 2013).

However, another possible explanation for reduced return probabilities of bypassed fish is that smaller fish and those in poorer condition are more likely to enter bypass systems (Zabel et al. 2005, Hostetter et al. 2015, Faulkner et al. 2019), and smaller fish, and fish in poorer condition, also have lower return probability (Ward and Slaney 1988, Zabel and Williams 2002, Evans et al. 2014). This suggests that apparent effects of juvenile bypasses on return probability could be at least in part due to correlation between bypass probability and fish size and condition, and not due to latent mortality effects caused by passage through the bypass itself. If true, the proposed increased levels of spill passage, while slightly improving direct survival rates of inriver migrating juveniles, may not increase adult returns to the levels hypothesized by the CSS.

There is also a risk that the high spill rates in the proposed action may have some negative effect as well as benefits to juvenile survival. High rates of spill frequently cause unbalanced flows in the tailrace resulting in the formation of large eddies. These conditions slow the passage of migrating smolts through the tailrace, exposing them to predators for a longer time. The operations in the proposed action also will result in higher total dissolved gas levels over longer periods than have been observed in recent years. Though higher TDG levels have been authorized by state environmental agencies, there remains the potential for some unanticipated negative effects of higher spill levels. These potential effects would most likely manifest under low flow, high spill percentage conditions, but there is insufficient information available (route-specific survival rates) to parameterize a model at present.

Many of these Snake River spring/summer Chinook salmon populations have been targeted for habitat restoration actions and will continue to be substantively influenced by hatchery produced fish. Estimated effects of habitat improvements were incorporated into the model at years 5, 10, and 15. This reflects a reasonable assumption about the implementation timing of the proposed action.

Three different tributary habitat models were used for the analysis of SR spring/summer Chinook. A single model was used for each MPG with the exception of Valley Creek in the Upper Salmon MPG which was analyzed with 2 different models. All of the models shared the same downstream migration survival model (COMPASS), ocean survival model, and adult upstream survival models. Each habitat model used a different set of parameters and algorithms to describe the relationship of observed rates of fish survival and production to environmental variables in spawning and rearing habitat. Since no model perfectly describes reality, use and comparison of different models may give a better estimate of probable outcomes. Detailed descriptions of these models are presented in Zabel and Jordan (2020).

The first model (Model 1) was used for the Upper Salmon and South Fork MPGs. The life-cycle models are life stage specific covering spawner to egg, egg to fry, fry to parr, parr to smolt, and smolt to spawner. All of the stage transitions are density dependent, with the exception of the smolt to spawner component. The redd and juvenile rearing capacity are estimated as functions of stream habitat quality and quantity. Stream habitat restoration actions were estimated to impact survival and carrying capacity for spawning, rearing, and juvenile life stage transitions. Since the basis of the freshwater habitat in these models is the reach type and geomorphic condition of the reaches, instream complexity actions were modeled to improve habitat quality and access actions to improve habitat quantity. In the climate change sensitivity analysis, this model did not have the capability of incorporating the effects on changing climate on the tributary phase of the life cycle.

The second model (Model 2) was used for the Middle Fork Salmon River MPG, the Valley Creek population (Upper Salmon MPG) and Secesh River population (South Fork Salmon MPG). The population responses were density dependent in the spawner to parr and parr to smolt stages. The environmental covariates included in the parr to smolt stage were fall stream flow and summer air temperatures in the Salmon River Basin. The model was most sensitive to capacity limitations in freshwater, especially parr and smolt carrying capacities in the current climate, and spawner maximum productivity under climate change scenarios (see Potential Future Effects of Climate Change). The primary strengths of this model were application and integration of climate drivers across all life stages. Potential limitations of this model include weak links to specific habitat limitations and potential future temperature constraints. In the climate change sensitivity analysis, this model incorporated the effects of a changing climate on all phases of the life cycle.

The third model (Model 3) was used for the Grande Ronde River MPG. For each population, the total amount of rearing habitat in reaches designated as in current use by ODFW above and below the location of the juvenile out-migrant traps was estimated. The results from a systematic survey of pools, fast water and run habitat units in Grande Ronde basin tributaries in combination with parr density estimates for each habitat category were then used to generate standardized habitat estimates of the total amount of habitat above and below the juvenile sampling weirs for each population.

The basic approach for incorporating habitat change effects starts with current life stage capacities and survival estimates derived from 20 plus year juvenile time series for each population. Using the results of ODFW Aquatic Inventory surveys in each population, we calculate the total amount of pool equivalent habitat currently supporting spawning and/or rearing. Other than scaling the expression of juvenile life stage parameters to the total amount of pool equivalent habitat within a population, our Grande Ronde life cycle models do not directly include habitat parameters. Instead, multipliers on life stage specific survival and capacity terms were used as inputs to model the impact of habitat actions or environmental changes.

Models were run for 1,000 iterations and the distribution of results are reported. We use percentiles to describe the distributions of results. The median is the point where 50 percent of the estimates are greater or less than that point, the 25th percentile is the point where 75 percent of the estimates are greater than that point, the 75th percentile represents the point where 25 percent of the estimates are greater than that point, and the 95th percentile and 5th percentile represent the upper and lower 5 percent of these distributions. In interpreting these results, we consider the estimates nearest the median to be the most likely outcome, with likelihood decreasing as estimates get further from the median. In the case of QET 50 the distribution represents the probability of dropping below a QET of a particular value, with the median representing the most likely value with the probability of other values decreasing as you move away from the median. A graphical example of how to properly interpret modeling results (median and 25th and 75th quartiles) is presented in Figure 2.2-10.

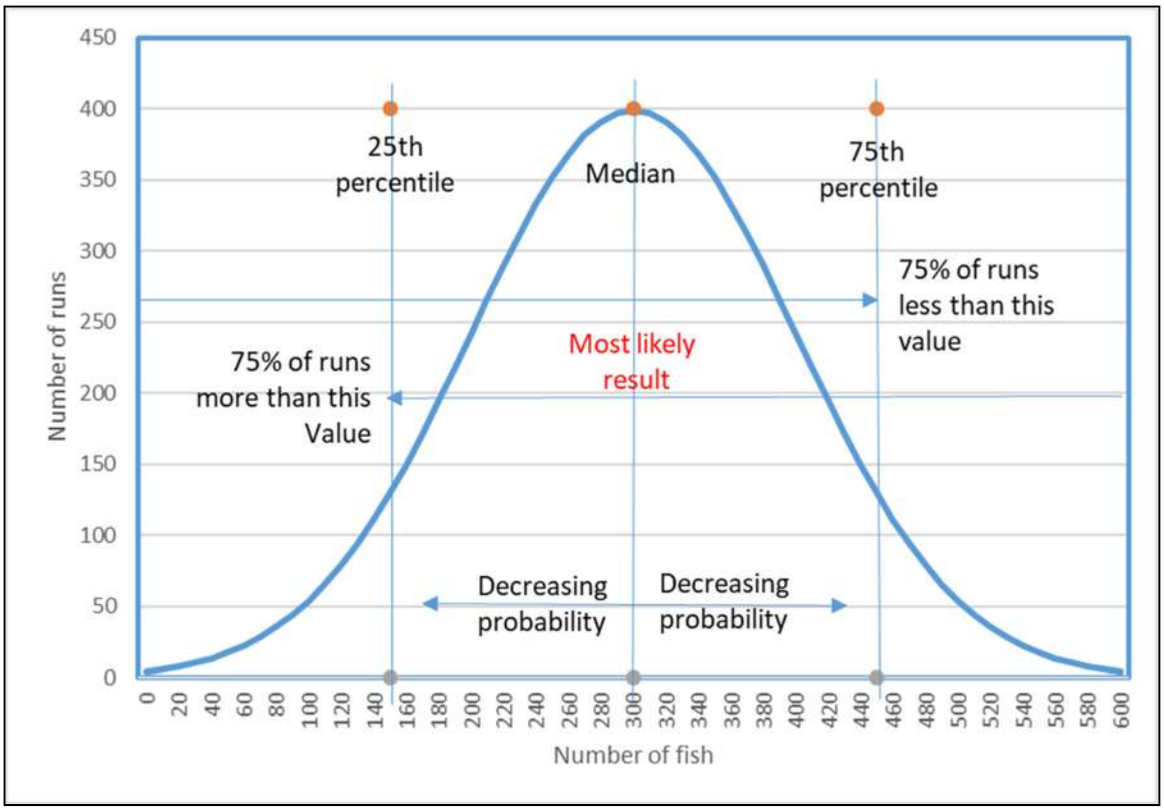


Figure 2.2-10. An example of how to interpret the results of model runs. Simulated results of 1000 runs represented in a normal distribution with 25th, median, and 75th percentiles indicated (vertical lines). Actual model runs may not be normally distributed, but the same principles of interpretation apply.

In the box plots presented below, the box represents the range from the 25th to 75th quartiles, with a horizontal line inside the box representing the median (most likely outcome). The "whiskers" represent the 5th and 95th percentiles, values that only 5 percent of the runs were less than or greater than respectively.

Grande Ronde River MPG

There was sufficient data available to support Life-cycle modelling of 5 populations from the Grande Ronde River MPG: Catherine Creek, Lostine River, Minam River, Upper Grande Ronde, and Wenaha River. The Catherine Creek, Lostine River, and Upper Grande Ronde are supplemented by conservation hatchery programs. Model results are presented for these populations for both hatchery and natural origin spawners, and only natural origin spawners. Model results are presented in Table 2.2-19a and 2.2-19b and in Figure 2.2-11a and 2.2-11b. This section includes a limited presentation of results for the sake of clarity. More detailed outputs are presented in Appendix C which also includes analyses assuming a latent mortality improvement of 17.5 percent (50 percent of the estimated value) and estimates of QET 30. The results of these analyses are intermediate between the two scenarios presented below.

Two populations in this MPG receive supplementation from hatchery programs, the Upper Grande Ronde and Catherine Creek. Results for these populations are presented for both total spawners (hatchery and natural origin) and only natural origin spawners. Comparison of estimates with and without hatchery supplementation may be used to infer the importance of these programs in supporting populations where habitat is substantially degraded.

For the hatchery supplemented populations, the projected geomean median abundance estimates (hatchery and naturally produced adults combined - year 15-24) are Catherine Creek (679), Lostine River (658), and Upper Grande Ronde (567). With the hypothesized 35 percent increase in productivity due to decreased latent mortality the geomean median abundance estimates are Catherine Creek (965), Lostine River (858), and Upper Grande Ronde (767).

Under the proposed action, the projected geomean median abundance estimate (natural origin spawners only - year 15-24) are Catherine Creek (313), Lostine River (233), Wenaha River (195) and Minam River (217). The estimate for the Upper Grande Ronde (66) the lowest of the populations modelled The contrast of population estimates with and without hatchery spawners indicates the importance of these programs in supporting populations where habitat has been substantially degraded. The hypothesized 35 percent increase in SARs of fish that migrated inriver (CSS hypothesis) projects substantially higher estimates of median abundance for all Grande Ronde populations (Table 2.2-19b), but the largest improvements were for the Minam River (288 percent) and Wenaha River (332 percent) populations. Large portions of the habitat of these populations is in wilderness areas, where density dependent effects in other life history stages due to degraded habitat are less likely to dampen the increased productivity that would be expected to occur in response to increased numbers of spawners.

The projected quasi-extinction risks (QET 50) for the three populations supported by hatchery programs, Catherine Creek, Lostine River, and Upper Grande Ronde are very low, with only the Catherine Creek having a median estimate greater than zero (0.02). This once again indicates the significance of these programs in supporting these populations where habitat is currently degraded.

The projected median Quasi-Extinction probabilities (QET 50) only considering natural origin spawners (Table 2.2-19b) are 0.25 or less for all populations except the Upper Grande Ronde (0.85) and Catherine Creek (0.40). As previously stated, comparison of these values with those that including hatchery spawners demonstrates the importance of the hatchery programs supporting these populations. As would be expected, the inclusion of the hypothesized 35 percent increase in productivity due to decreases in latent mortality decreased probability of QET 50 from 44-57 percent, with the exception of the Upper Grande Ronde (9 percent). This smaller reduction in the probability of QET 50 when only natural spawners are considered likely reflects the influence of degraded habitat, limiting the ability of the Upper Grande Ronde population to positively respond to increased numbers of spawners.

Table 2.2-19a. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Grande Ronde River MPG populations of hatchery and naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality.

Grande Ronde River MPG hatchery and natural origin spawners	Abundance			QET = 50		
Population	**25th**	**Median**	**75th**	**25th**	**Median**	**75th**
Catherine Creek						
Proposed Action	491	679	950	0.00	0.01	0.01
Proposed Action +35%	692	965	1307	0.00	0.00	0.00
Lostine River						
Proposed Action	519	658	846	0.00	0.00	0.00
Proposed Action +35%	681	858	1083	0.00	0.00	0.00
Upper Grande Ronde						
Proposed Action	426	567	768	0.00	0.00	0.00
Proposed Action +35%	595	767	1035	0.00	0.00	0.00

Table 2.2-19b. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Grande Ronde River MPG populations of naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality.

Grande Ronde River MPG natural origin spawners	Abundance			QET = 50		
Population	**25th**	**Median**	**75th**	**25th**	**Median**	**75th**
Catherine Creek						
Proposed Action	226	313	446	0.26	0.29	0.32
Proposed Action +35%	320	451	620	0.09	0.11	0.14
Lostine River						

Grande Ronde River MPG natural origin spawners	Abundance			QET = 50		
Population	**25th**	**Median**	**75th**	**25th**	**Median**	**75th**
Proposed Action	173	233	325	0.01	0.02	0.03
Proposed Action +35%	246	336	448	0.01	0.01	0.02
Minam River						
Proposed Action	29	217	853	0.27	0.31	0.33
Proposed Action +35%	170	843	2155	0.20	0.22	0.25
Upper Grande Ronde						
Proposed Action	50	66	87	0.93	0.94	0.95
Proposed Action +35%	66	85	114	0.81	0.83	0.85
Wenaha River						
Proposed Action	58	195	616	0.22	0.25	0.27
Proposed Action +35%	301	844	2105	0.12	0.14	0.17

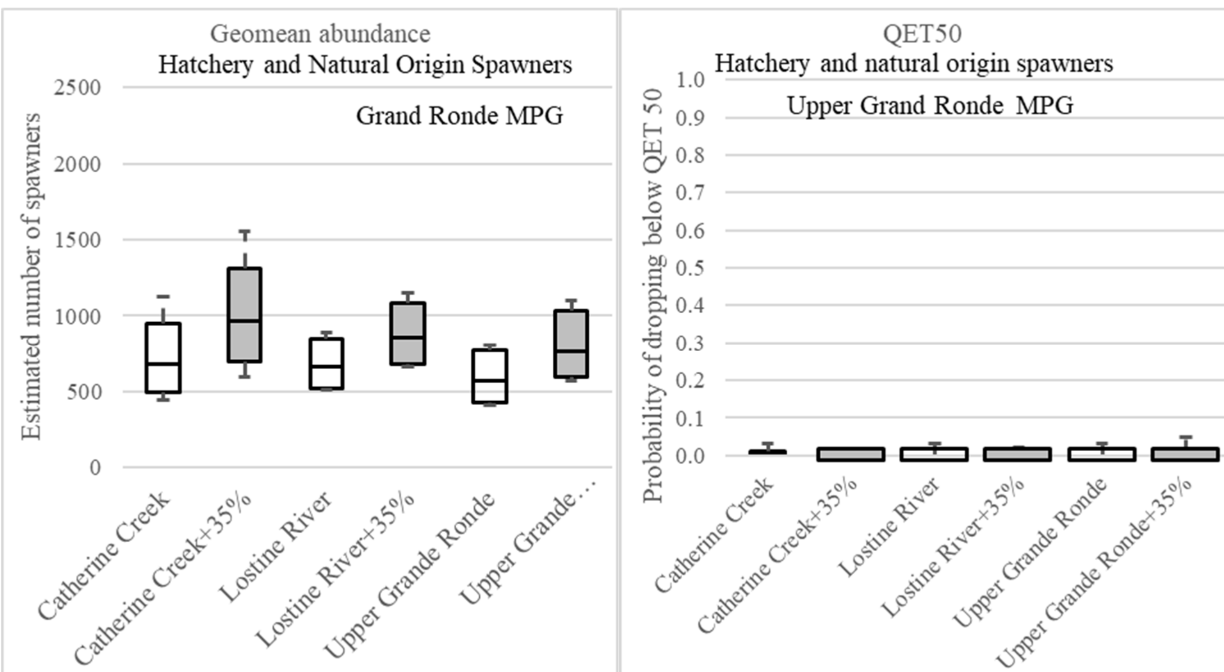


Figure 2.2-11a. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Grande Ronde River MPG populations of hatchery and naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Boxes represent the 25^{th}-75^{th} percentiles, the horizontal line inside the box represents the median (most likely) value, and the “whiskers” represent the 5^{th} and 95^{th} percentiles.

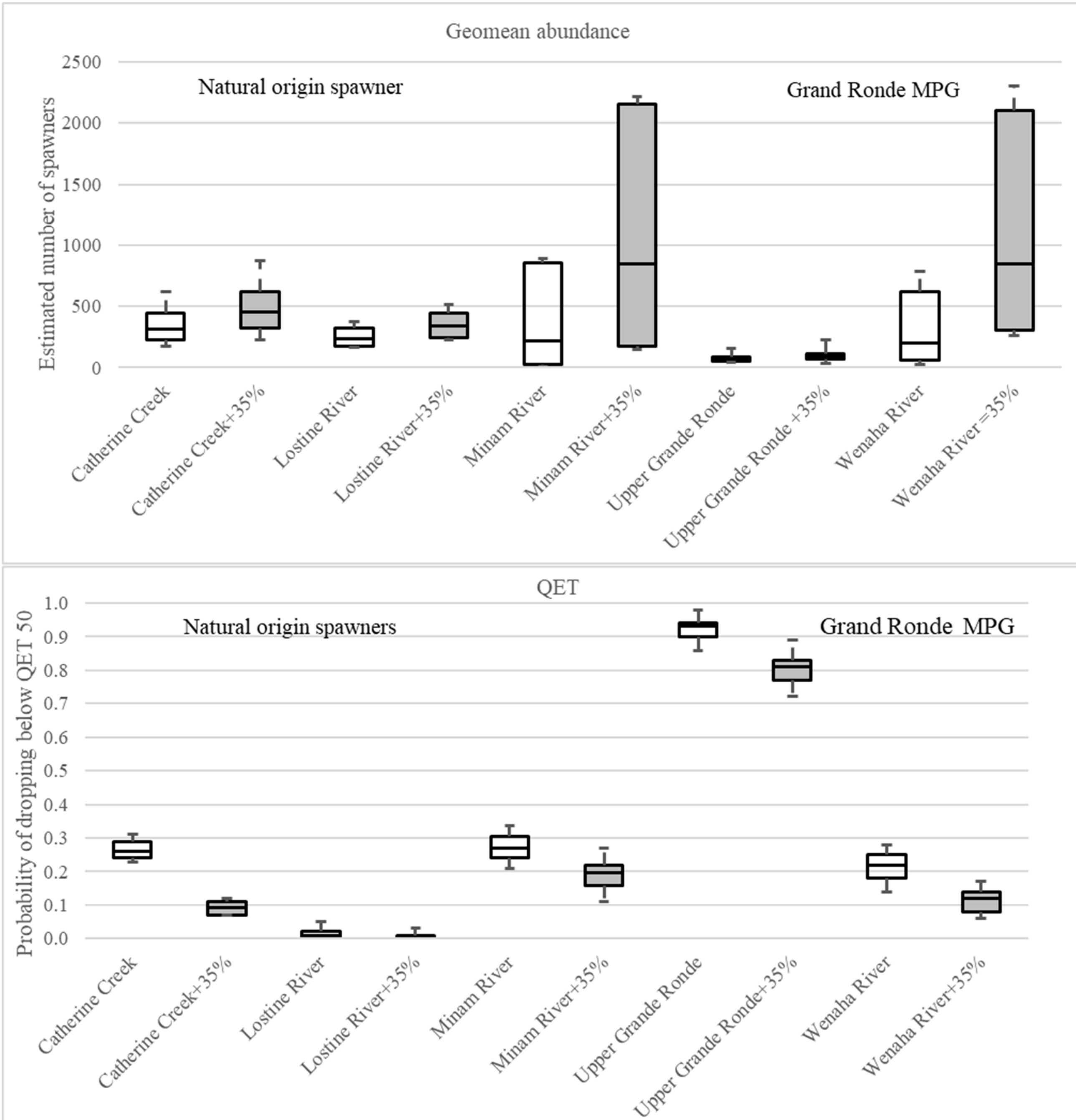


Figure 2.2-11b. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Grande Ronde River MPG populations of naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Boxes represent the 25th-75th percentiles, the horizontal line inside the box represents the median (most likely) value, and the "whiskers" represent the 5th and 95th percentiles.

South Fork Salmon River MPG

There was sufficient information available to support life-cycle modeling in one of the four populations that comprise the South Fork Salmon River MPG. Model results are displayed in Table 2.2-20 and in Figure 2.2-12. This population was modelled using Model 2 as identified above in the introduction to section 2.2.3.1.12. This section includes a limited presentation of results for the sake of clarity. More detailed outputs are presented in Appendix C which includes analyses incorporating a latent mortality improvement of 17.5 percent and estimates of QET 30.

Under the proposed action, the projected median abundance estimate (year 15 to 24) for the Secesh River population is 556 spawners. The projected median probability of falling below the QET 50 threshold is relatively low, about three percent. The projected median geomean abundance estimate for the proposed action and a 35 percent increase in SARs of fish that migrated inriver (CSS hypothesis) is 840, or a 56 percent increase in abundance; the projected median QET 50 is reduced to about one percent.

Table 2.2-20. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for South Fork Salmon MPG populations of naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality.

South Fork Salmon MPG	Estimated Abundance			Probability of QET 50		
Population	**25th**	**Median**	**75th**	**25th**	**Median**	**75th**
Secesh River						
Proposed Action	364	556	916	0.02	0.03	0.04
Proposed action + 35%	539	840	1357	0.00	0.01	0.02

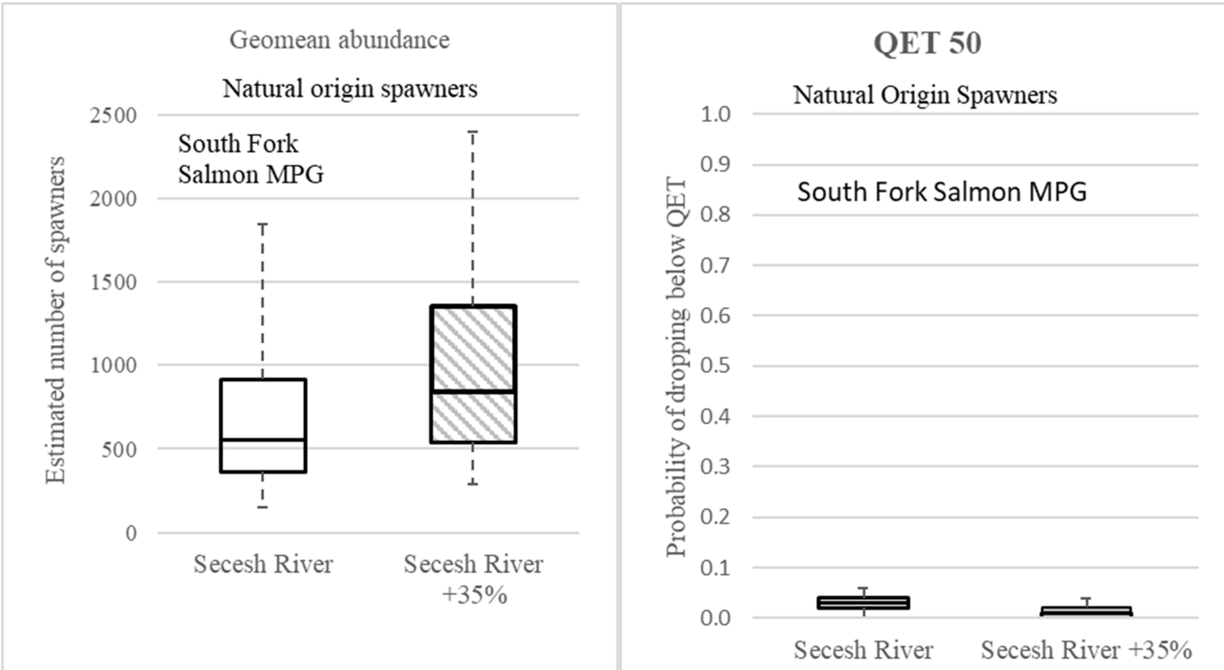


Figure 2.2-12. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for the South Fork Salmon MPG (Secesh River population) of naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Boxes represent the 25th-75th percentiles, the horizontal line inside the box represents the median (most likely) value, and the "whiskers" represent the 5th and 95th percentiles.

Middle Fork Salmon River MPG

As previously noted, within the Middle Fork Salmon River MPG, six populations were modeled: Big Creek, Bear Valley Creek, Camas Creek, Loon Creek, Marsh Creek, and Sulphur Creek. Model results are displayed in Table 2.2-21 and in Figure 2.2-11. There is little hatchery influence in this ESU so the analysis only includes natural origin The life-cycle model used for these populations (Model 2) does not incorporate an estimate of productivity increases due to past habitat improvements and no habitat improvement action are proposed. Smolt productivity and carrying capacities in this model are not fixed, but vary with flow and temperature. This section includes a limited presentation of results for the sake of clarity. More detailed outputs are included in Appendix C, which includes analyses incorporating a latent mortality improvement of 17.5 percent and estimates of QET 30.

Under the proposed action, the projected median geomean abundance estimate (year 15 to 24) for the Bear Valley, Marsh Creek, and Big Creek populations are 412, 269, and 194, respectively. The projected median probability of falling below the QET 50 threshold for these populations ranges from 0.04 to 0.11. The projected median abundance estimates for the proposed action and a 35 percent increase in SARs of fish that migrated inriver (CSS hypothesis) for these populations are 622, 395, and 262, respectively, a 35 to 51 percent increase in abundance; and the projected median QET 50 estimates are reduced to 0.01 to 0.04 for these populations, a reduction of 64 to 75 percent.

Under the proposed action, the projected median geomean abundance estimates for the smaller Sulphur, Camas, and Loon creek populations range from about 54 to 74 spawners. The projected median probabilities of falling below the QET 50 threshold for these populations are relatively high, ranging from 0.77 to 0.88. The projected median abundance estimates for the proposed action and a 35 percent increase in SARs of fish that migrated inriver (CSS hypothesis) for these populations ranges from 54 to 72 spawners, an increase of between 39 and 50 percent; and the projected median QET 50 estimates are reduced to 0.70 to 0.86 for these populations, a reduction of about 17 to 31 percent.

Table 2.2-21. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Middle Fork Salmon MPG populations of naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality.

Middle Fork Salmon MPG	Abundance			QET = 50		
Population	**25th**	**Median**	**75th**	**25th**	**Median**	**75th**
Bear Valley						
Proposed Action	242	412	663	0.02	0.04	0.05
Proposed Action +35%	375	622	993	0.00	0.01	0.02
Big Creek						
Proposed Action	135	194	282	0.09	0.11	0.13
Proposed Action +35%	181	262	380	0.03	0.04	0.06
Camas Creek						
Proposed Action	37	54	82	0.83	0.86	0.88
Proposed Action +35%	51	75	114	0.67	0.71	0.73
Loon Creek						
Proposed Action	52	74	106	0.67	0.70	0.73
Proposed Action +35%	69	100	142	0.47	0.50	0.53
Marsh Creek						
Proposed Action	154	269	445	0.09	0.11	0.13
Proposed Action +35%	225	395	642	0.03	0.04	0.05
Sulphur Creek						
Proposed Action	47	72	118	0.71	0.74	0.77
Proposed Action +35%	70	108	175	0.48	0.51	0.54

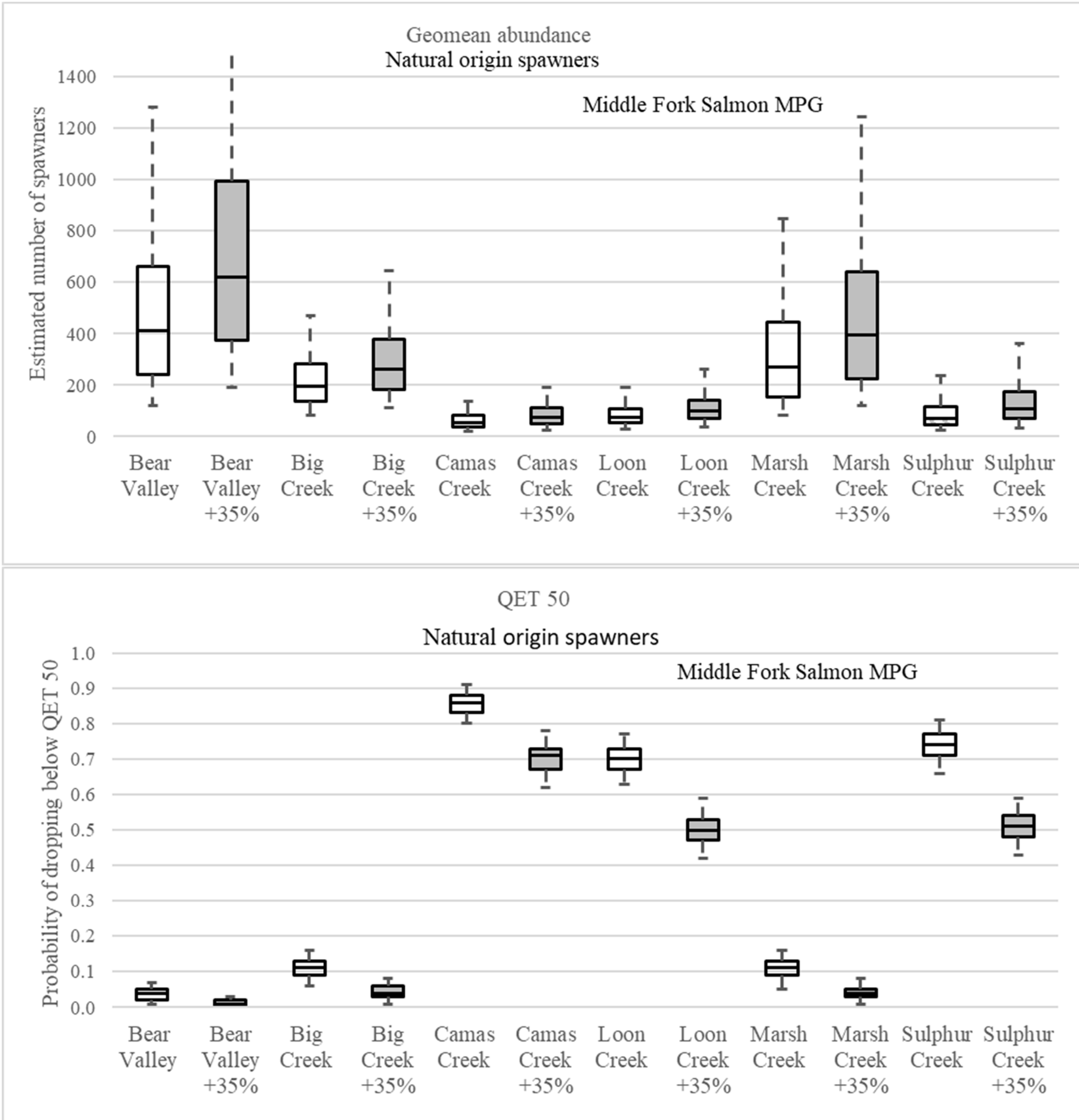


Figure 2.2-13. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Middle Fork Salmon MPG populations of naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Boxes represent the 25th-75th percentiles, the horizontal line inside the box represents the median (most likely) value, and the "whiskers" represent the 5th and 95th percentiles.

Upper Salmon River MPG

As previously noted, within the Upper Salmon River MPG, seven populations have sufficient information available to support Life-cycle modeling: East Fork Salmon, North Fork Salmon, Panther Creek, Valley Creek, Yankee Creek, Lemhi River, and Upper Mainstem Salmon. Habitat improvements that were incorporated into the model for each population are presented in Table 2.2-22. Model results are presented in Table 2.2-23 and in Figure 2.2-14. This section includes a limited presentation of results for the sake of clarity. More detailed outputs are presented in Appendix C, which includes analyses incorporating a latent mortality improvement of 17.5 percent and estimates of QET 30.

Two populations in this MPG receive supplementation from hatchery programs, the Pahsimeroi and Upper Salmon. Results for these populations are presented for both total spawners (hatchery and natural origin) and only natural origin spawners. Comparison of estimates with and without hatchery supplementation may be used to infer the importance of these programs in supporting populations where habitat is substantially degraded.

For the two populations receiving hatchery supplementation, the projected geomean median abundance estimate (year 15 to 24) of both hatchery and natural spawners were 372 in the Pahsimeroi and 559 in the Upper Salmon population, respectively. Inclusion of the hypothesized 35 percent increase in productivity due to latent mortality reductions increased the Pahishmeroi by 38 percent and the Upper Salmon by 40 percent. The probability of quasi-extinction (QET 50) was essentially 0.00 for both populations with and without the latent mortality productivity increase.

Only considering natural origin spawners, under the proposed action, the projected geomean median abundance estimate (year 15 to 24) for the larger Pahsimeroi and Upper Mainstem populations are 266 and 478, respectively. The projected median probabilities of falling below the QET 50 threshold for these populations are 0.18 and 0.01, respectively. The projected median geomean abundance estimates for the proposed action and a 35 percent increase in SARs of fish that migrated inriver (CSS hypothesis) for these populations are 404 and 697. This is a 46 to 52 percent increase in abundance; and the projected median QET 50 would decrease to 0.06 and zero, respectively.

Under the proposed action, the projected geomean median abundance estimates of natural origin spawners for the intermediate East Fork, Lemhi, and Panther Creek populations range from about 78 to 135 spawners. The projected median probability of falling below the QET 50 threshold for these populations ranges from 0.28 to 0.62. The projected median geomean abundance estimate for the proposed action and a 35 percent increase in SARs of fish that migrated inriver (CSS hypothesis) for these populations ranges from 108 to 292 spawners, an increase of between 38 and 183 percent; and the projected median QET 50 estimates are reduced to 0.05 to 0.27 for these populations, a reduction of about 30 to 85 percent.

Valley Creek was analyzed using two different models, the model used for all the other populations in this section (Model 1), and the model used to analyze the Middle and South Fork Salmon populations (Model 2). These models primarily differ in how they incorporate proposed habitat improvements in their calculations. Model 1 creates an estimate of the effects of habitat improvements on productivity, while Model 2 does not incorporate habitat improvements. The estimated median geomean spawner abundance for Models 1 and 2 were 35 and 69 spawners. The QET 50 estimates were 0.85 and 0.48 respectively. Addition of the hypothesized 35 percent latent mortality productivity increase raised the Model 1 abundance estimate to 88 and the Model 2 estimate to 97. QET 50 dropped to 0.46 and 0.25. The stronger response of Model 1 to the increased productivity results from the lower initial population sizes estimated by Model 1 and thus less constraint from density dependence than Model 2.

The small populations in the Upper Salmon MPG, North Fork, Panther Creek, Valley Creek (discussed above), and Yankee Fork all remained relatively small under the proposed action with median spawner abundance estimates of 25, 78, 35,69, and 74 spawners, respectively. The QET 50 probabilities ranged from 0.35-0.95. The projected median geomean abundance estimate for the proposed action and a 35 percent increase in SARs of fish that migrated inriver (CSS hypothesis) increased substantially, from 43-156 percent. The corresponding QET 50 probabilities were reduced by 30-55 percent. However, even with these improvements spawner abundance remained relatively low and QET 50 probability relatively high.

Figure 2.2-14a and 2.2-14b shows the projected median geomean abundance under both the proposed action and proposed action plus 35 percent increase in SAR, for natural origin adult spawners only, and for total spawners (including hatchery fish) for the Pahsimeroi and Upper Mainstem Salmon populations. As expected, the inclusion of hatchery origin spawners in addition to natural origin spawners increases the total abundance of spawners in these populations substantially.

Table 2.2-22. Habitat improvements modelled in the Upper Salmon MPG analysis.

	Lemhi	Pahsimeroi	Upper Mainstem Salmon
Instream Complexity Total in15yrs[km]	15.2	0.0	15.2
Instream Complexity per interval in5yrs[km]	5.0	0.0	5.0
Instream Complexity area Total in15yrs[m^2]	167,200.0	0.0	69,920.0
Instream Complexity area per interval in5yrs [m^2]	55,176.0	0.0	23,073.6

	Lemhi	Pahsimeroi	Upper Mainstem Salmon
Current spawn/rear area [m^2]	1,500,711.0	594,315.0	730,453.0
Relative increase in area per interval in 5yrs [%]	3.7%	0.0%	3.2%
Habitat Access Total in 15yrs [km]	28.5	28.5	28.5
Habitat Access per interval in 5yrs[km]	9.4	9.4	9.4
Habitat Access area total in15yrs [m^2]	103,498.6	119,493.8	43,281.2
Habitat Access area per interval in 5yrs [%]	2.3%	6.6%	2.0%

Table 2.2-23. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Upper Salmon MPG populations of naturally produced fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality.

Upper Salmon MPG	Abundance			QET 50		
Hatchery and Natural spawners	**25th**	**Median**	**75th**	**25th**	**Median**	**75th**
Pahsimeroi						
Proposed Action	295	372	470	0.00	0.00	0.00
Proposed Action +35%	401	515	667	0.00	0.00	0.00
Upper Mainstem Salmon						
Proposed Action	418	559	717	0.00	0.00	0.00
Proposed Action +35%	573	785	1033	0.00	0.00	0.00
East Fork Salmon						
Proposed Action	80	135	228	0.24	0.28	0.30
Proposed Action +35%	190	292	426	0.04	0.05	0.06
North Fork Salmon						
Proposed Action	12	25	47	0.92	0.94	0.95
Proposed Action +35%	39	64	98	0.62	0.65	0.67
Panther Creek						
Proposed Action	61	78	98	0.60	0.62	0.66
Proposed Action +35%	84	108	134	0.25	0.27	0.29
Valley Creek						

Upper Salmon MPG	Abundance			QET 50		
Hatchery and Natural spawners	**25th**	**Median**	**75th**	**25th**	**Median**	**75th**
Proposed Action	16	35	63	0.82	0.85	0.86
Proposed Action +35%	51	88	138	0.43	0.46	0.49
Valley Creek (2)						
Proposed Action	106	69	174	0.45	0.48	0.51
Proposed Action +35%	150	97	244	0.26	0.29	0.32
Yankee Fork						
Proposed Action	57	74	97	0.65	0.67	0.71
Proposed Action +35%	80	106	140	0.26	0.30	0.33
Lemhi						
Proposed Action	40	87	180	0.33	0.35	0.38
Proposed Action +35%	142	246	419	0.04	0.05	0.07
Pahsimeroi						
Proposed Action	197	266	365	0.15	0.18	0.20
Proposed Action +35%	294	404	548	0.05	0.06	0.07
Upper Mainstem Salmon						
Proposed Action	343	478	629	0.00	0.01	0.01
Proposed Action +35%	494	697	932	0.00	0.00	0.00

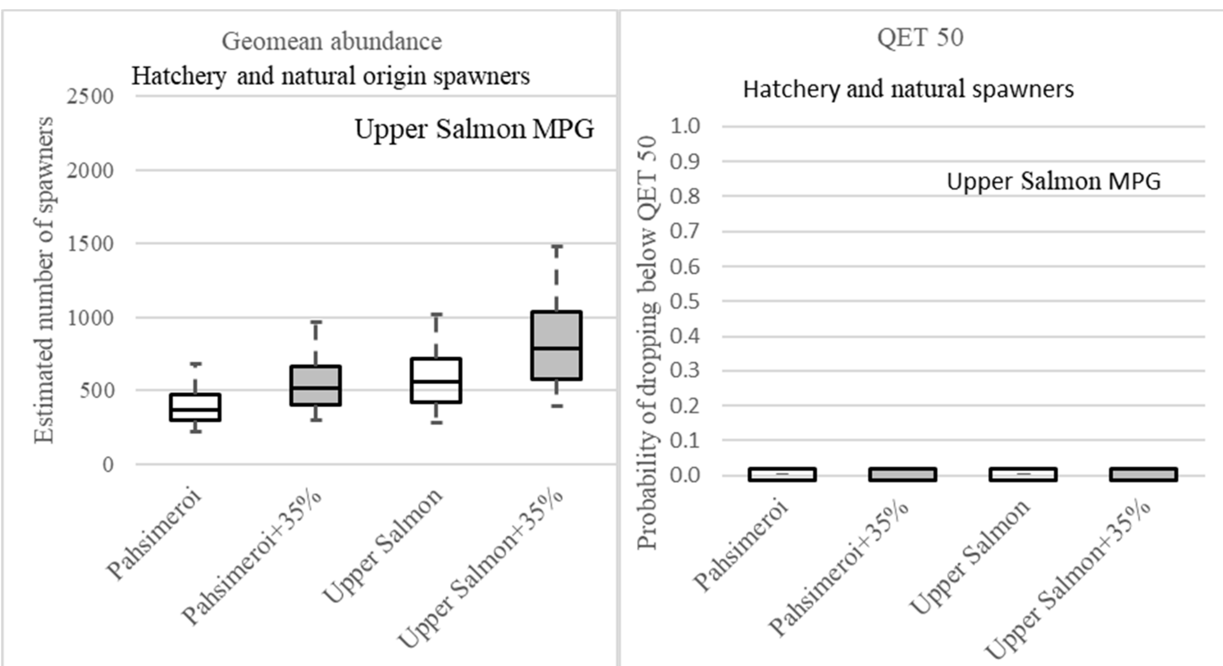


Figure 2.2.-14a Life-cycle model projections of median abundance of Pahsimeroi and Upper Salmon populations when hatchery spawners from the integrated hatchery programs are included. Life-cycle model projections of median abundance of fish in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase

in survival resulting from CSS hypothesized reductions in latent mortality. Boxes represent the 25th-75th percentiles, the horizontal line inside the box represents the median (most likely) value, and the "whiskers" represent the 5th and 95th percentiles. Natural origin spawners (NOS) are included for comparison with the total number of natural origin and hatchery spawners (all).

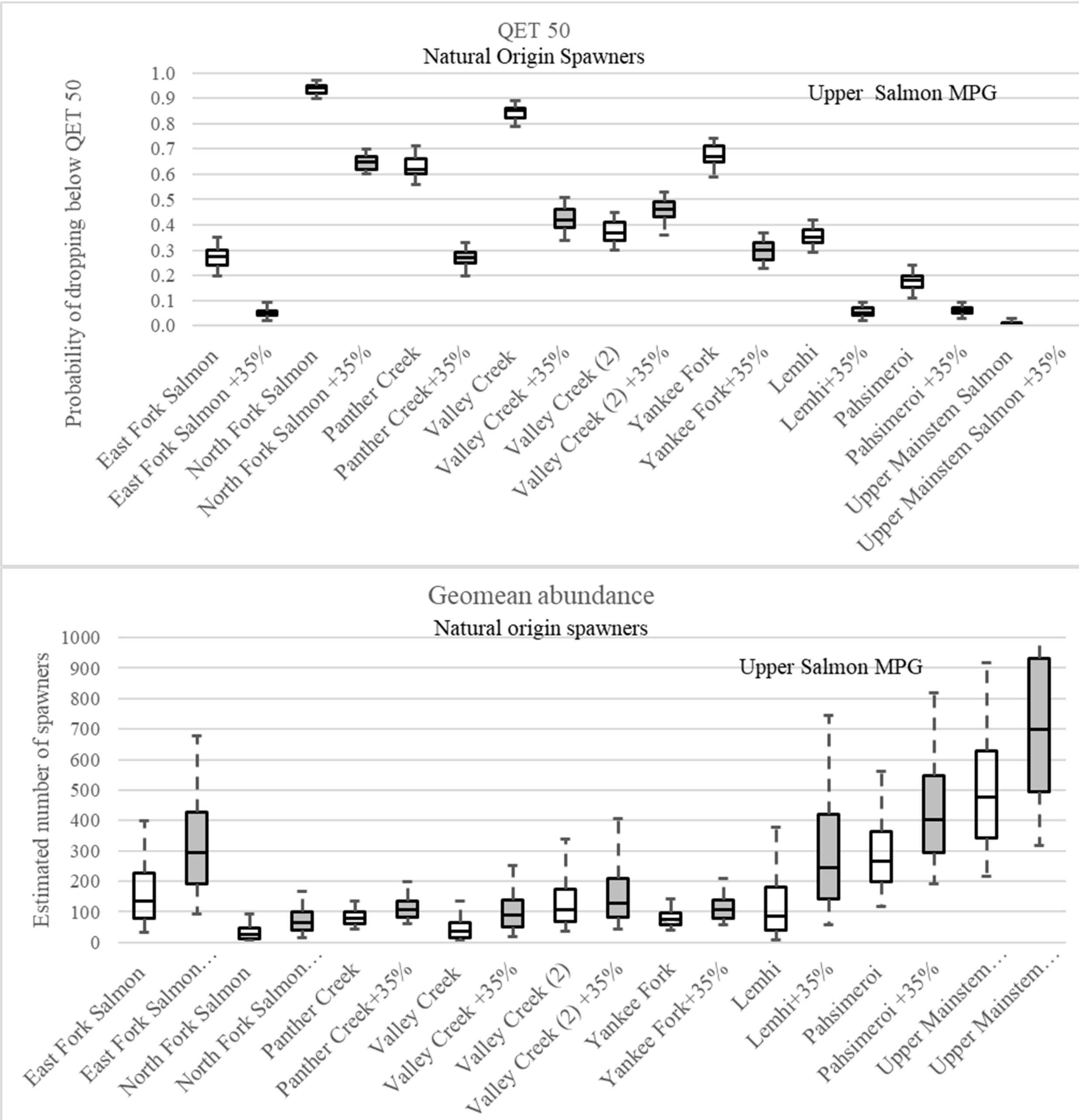


Figure 2.2-14b. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Upper Salmon River MPG populations of hatchery and natural origin spawners in 24 years (year 15 to 24) under the proposed action, and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Boxes represent the 25th-75th percentiles, the horizontal line inside the box represents the median (most likely) value, and the "whiskers" represent the 5th and 95th percentiles.

Summary

Life-cycle models are limited by the amount and quality of the available data that can be used to estimate, or infer, relationships to factors that influence the survival and productivity of individuals within a population throughout their life cycle. The life-cycle models presently do not model interactions between populations (straying, source-sink dynamics etc.) or between MPGs explicitly, though these dynamics are generally known to occur. The models essentially assume that these processes are represented in the levels of abundance and variability exhibited by recent population counts. How these processes might change dynamics in the future is not currently known. That said, the models provide useful frameworks for assessing how populations (in isolation) are likely to respond to factors that are correlated with survival or abundance.

The projected median geomean abundance estimates indicate that under the proposed action (without considering potential increases in SARs from hypothesized reductions in latent mortality), each MPG would be expected to continue to have at least one population with 250 to 300 or more spawners, and correspondingly, a relatively low (0 to about 20 percent) risk of falling below the QET 50 thresholds. Each MPG would also continue to have smaller populations (less than 100 spawners), that would continue to be at much higher (75 to 95 percent) risk of falling below the QET 50 thresholds. These smaller populations tend to inhabit areas that have suffered from severe habitat degradation unrelated to the CRS operations (Yankee Fork), or that inhabit higher elevation, relatively unproductive habitat (e.g., Sulphur Creek, Camas Creek, Loon Creek, North Fork Upper Salmon, and East Fork Upper Salmon).

There are also examples of populations that would be expected to be intermediate, between these two groups of populations. As noted previously in the environmental baseline, these larger, more productive populations are very important to the persistence and integrity of each MPG. Adults from these populations undoubtedly stray into, and spawn with, adults in nearby, less productive and abundant populations, supporting their persistence and increasing the overall demographic and genetic resiliency of each MPG. It is important to note that the modeled abundance estimates (and resulting QET estimates) incorporate many factors beyond those explicitly modeled (i.e., juvenile survival of migrating and transported juveniles, pinniped predation, tributary habitat improvements, hatchery spawners, etc.). Examples include the likely effects of non-native species, increased avian predation in the estuary, and changing biological and physical conditions in the marine environment. Because the base data for model development are estimates of spawners over some relatively recent period of time, all factors that can affect survival across their entire life cycle (not just those factors for which we have empirical, modeled relationships) are incorporated in the models.

The DRAFT Environmental Impact Statement used COMPASS to compare the Preferred Alternative (Proposed Action) to the No Action Alternative (2016 operations) (USACE et al. 2020) for Snake River spring/summer Chinook salmon. The median model results (USACE et al. 2020, Tables 7-24 and 25) indicated that the flexible spring spill operation (Proposed Action), compared to the No Action Alternative would:

- Slightly increase juvenile survival for inriver migrants from 42.7 to 42.8 percent;
- Reduce travel times from 17.7 to 16.5 days;
- Substantially reduce the proportion of fish transported from 38.5 to 19.0 percent; and
- Reduce overall Lower Granite to Bonneville SARs from 0.88 to 0.81 percent (assuming there would be no productivity increases associated with the CSS's latent mortality hypothesis).

The reduction in Lower Granite to Bonneville SARs was primarily attributed to the substantial reduction in the proportion of transported fish due to increased spill levels at the collector projects, especially in May and June, when SARs of transported smolts are often higher than those of inriver migrating smolts. The median model results (USACE et al. 2020, Table 7-25) also indicated that, about a 10 percent increase in productivity (stemming from the CSS's latent mortality hypothesis) would be required to offset this aggregate (includes both transported and inriver migrants) SAR reduction. The CSS hypothesized that the Proposed Action would result in a 35 percent increase in Lower Granite to Bonneville SARs.

Habitat restoration actions are expected to slightly improve the productivity (and, in some cases, the carrying capacity) of the targeted tributaries in the Upper Salmon MPG within the modelled 24-year timeframe. As noted previously, the full benefit of some habitat restoration actions would not be fully realized for many decades. Hatchery supplementation will increase the abundance of total spawners in the targeted tributaries, providing an additional buffer against reduced abundance in these populations (reducing QET 50 probabilities calculated using only natural origin spawners), although there may be other negative effects of hatchery supplementation that were not modeled.

Under the proposed action with an additional 35 percent increase survival (i.e., CSS hypothesized SAR increases), the projected median geomean abundance of all populations in these MPGs would increase by about 38 to 332 percent; and the median probability of falling below the QET 50 thresholds would decrease by about 12 to 62 percent.

Thus, the life-cycle modeling results underscore the importance of the scientific debate over latent mortality. If latent mortality is substantially affecting smolt-to-adult returns of Snake River spring/summer Chinook, and can be addressed either operationally (a central rationale to the flexible spring spill operation of the proposed action) or via other means, then populations would be expected to respond strongly, at least until some other constraint limits productivity (for example, density dependent capacity limitations). Alternatively, if latent mortality is relatively small, or cannot be addressed operationally, or by other means, then increased survival and productivity stemming from hydropower operations or configurational changes are likely to be substantially limited in scope, and improvements beyond what can be estimated in terms of direct survival increases are unlikely to materialize. The life-cycle modeling therefore supports the idea that learning how SARs and populations respond to the flexible spring spill operation (which is proposed as part of the adaptive management process described in the BA [BPA et al.

2020]) is extremely important for informing future management decisions relating to the CRS and other important processes (e.g., Recovery Plan implementation).

Potential Future Effects of Climate Change

A sensitivity analysis for the potential effects of climate change on modelling predictions was conducted by the NWFSC using Representative Concentration Pathway (RCP) 8.5. This scenario assumes actions to curb greenhouse gas emissions are limited. Expected changes in environmental drivers that significantly affect life-cycle model results are illustrated in Figure 2.2-15. The line labelled "stationary" assumes there is no trend in environmental conditions in the near future.

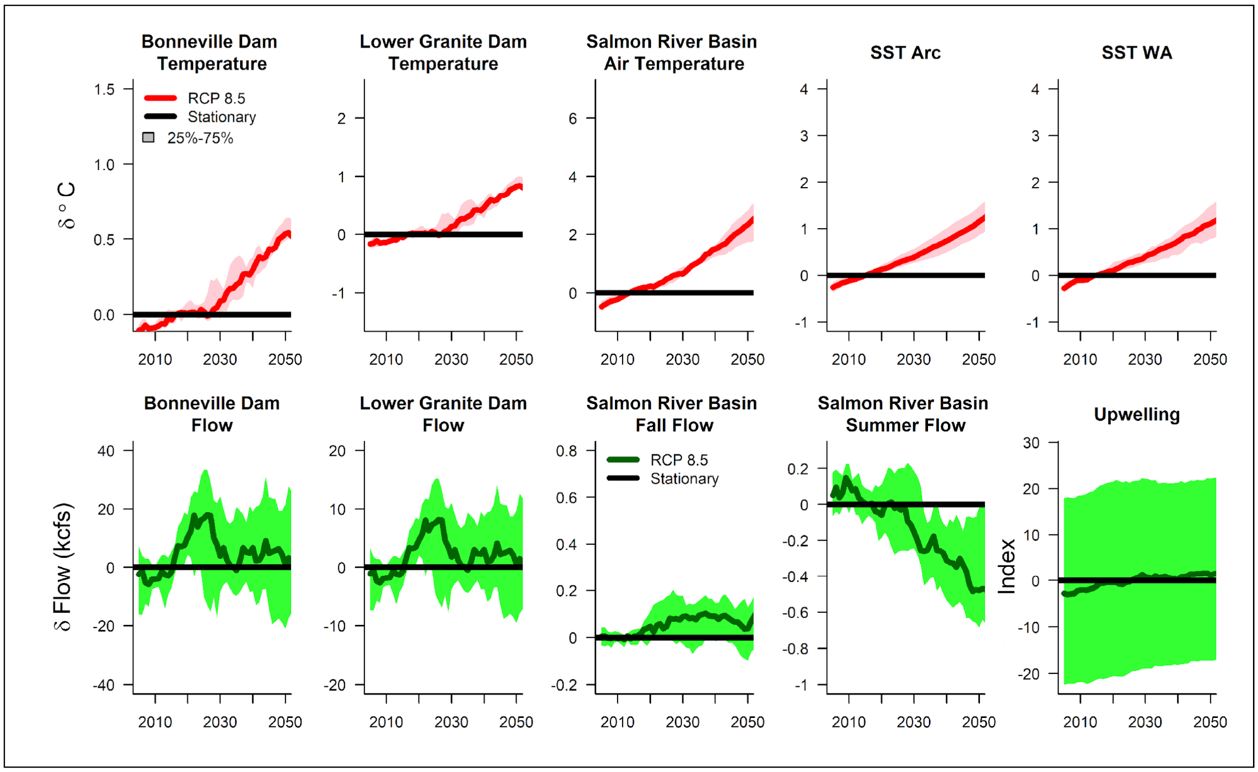


Figure 2.2-15. Changes from historical climate conditions as predicted by RCP8.5 (Bonneville Dam temperature, Lower Granite Dam temperature and Salmon River Basin air temperature), SST ARC is a reconstructed set sea surface temperature data, and SST WA is sea surface temperature off the coast of Washington. The period of the analyses conducted is 2036-2046.

The climate change analysis was conducted by running the same life-cycle models and the same proposed action, but with environmental conditions projected by global climate models run with the RCP4.5 and RCP8.5 emissions scenarios for comparison with a stationary climate. The climate scenarios influence stage transitions throughout the life cycle. We currently have statistical support for an important role of climate drivers in the spawner to smolt, downstream migration, smolt to adult, and upstream survival stages. For example, tributary and river basin scale metrics of temperature and flow influence parr survival (e.g. Crozier et al. 2008a, Crozier et al. 2010). The impact of environmental conditions on downstream survival has been extensively studied in development of the COMPASS model, which was used to model migration survival under future scenarios. However, we did not attempt to model how adaptive management of the hydrosystem might respond to information about migration timing, etc. (i.e., starting spill or transport operations earlier as a response to earlier migration timing). Upstream survival is also sensitive to environmental conditions, especially high flows for early-run populations, and high temperatures for late-run populations (Crozier et al. 2017a). Modeling of upstream survival also considered adult migration timing might change in response to warming temperatures (e.g., earlier migration timing to avoid stressful temperatures) (Crozier et al, in press, PLOS ONE).

Populations in the North Salmon MPG were analyzed using Model 1 (2.2.3.1.12 Life-Cycle Models) a life-cycle model that only incorporates climate change effects in the downstream migration, ocean, and upstream migration stages (Lower Granite to Lower Granite). The effects of climate change as described in RCP8.5 were not quantitatively analyzed for the freshwater rearing stage for these populations because the model does not have that capability. In the populations modelled by Model 2, the Middle Salmon MPG and Yankee fork population from the North Salmon MPG, and Model 3, The Grande Ronde/Imnaha MPG (2.2.3.1.12 Life-Cycle Models), the life-cycle models estimated the effect of climate change under RCP8.5 on all life stages.

To account for anthropogenic carbon emissions, we extracted trends from global climate model (GCM) projections of RCP4.5 and RCP8.5 emission scenarios. The climate scenarios were modelled using the ensemble approach, as advocated by the Intergovernmental Panel on Climate Change (IPCC 2014). This approach addresses uncertainty in model assumptions by using as many different models as possible. There are 26 GCMs available for each emissions scenario from Coupled Model Intercomparison Project CMIP5, available from NOAA's Earth Systems Research Laboratory (Alexander et al. 2018). Scientists at the University of Washington downscaled output from 10 of those GCMs using multiple downscaling methods, and processed the output through four different hydrological models to produce 80 different time series for naturalized flow across the Columbia River Basin (RMJOC 2018, Chegwidden et al. 2019). Different GCMs and hydrological models projected more or less change in a given environmental variable, reflecting differences in model characteristics. To capture this range of environmental projections, we modeled population responses to the lower quartile, mean, and upper quartile time series available for each emissions scenario. Thus we represented model uncertainty by including examples of relatively slow warming, relatively fast warming, and the ensemble mean projection.

To calculate the impact of climate change, tri-monthly divergences were calculated from a reference period of 2005-2025 mean for each time series. Then a 20-year running mean of the resulting annual anomalies was calculated for each time series. The 25^{th}, 50^{th} and 75^{th} quantiles of the differences were selected across all time series. These quantiles represent the spread across climate models of low, medium, and high rates of change in climate conditions under the assumptions of RCP 4.5 and RCP 8.5.

The RCP 4.5 and RCP 8.5 scenarios produced overlapping temperature projections over the next two decades, causing the results of the two scenarios to overlap substantially. The primary driver in the near-term climate is the amount of carbon already in the atmosphere, which is essentially the same for all future emissions scenarios. This is evidenced by the fact that the 50th percentile projection for the RCP 4.5 scenario is nearly the same as the 25th percentile projection for the RCP 8.5 scenario. Similarly, the 75th percentile projection for the RCP4.5 scenario is nearly the same as the 50th percentile projection for the RCP8.5 scenario (Figure 2.2-16). Because of the substantial overlap between the two scenarios, and to improve clarity, only RCP8.5 projections are discussed in the remainder of this section. However, all of the RCP4.5 and RCP8.5 results are presented, in tabular form, in Appendix C.

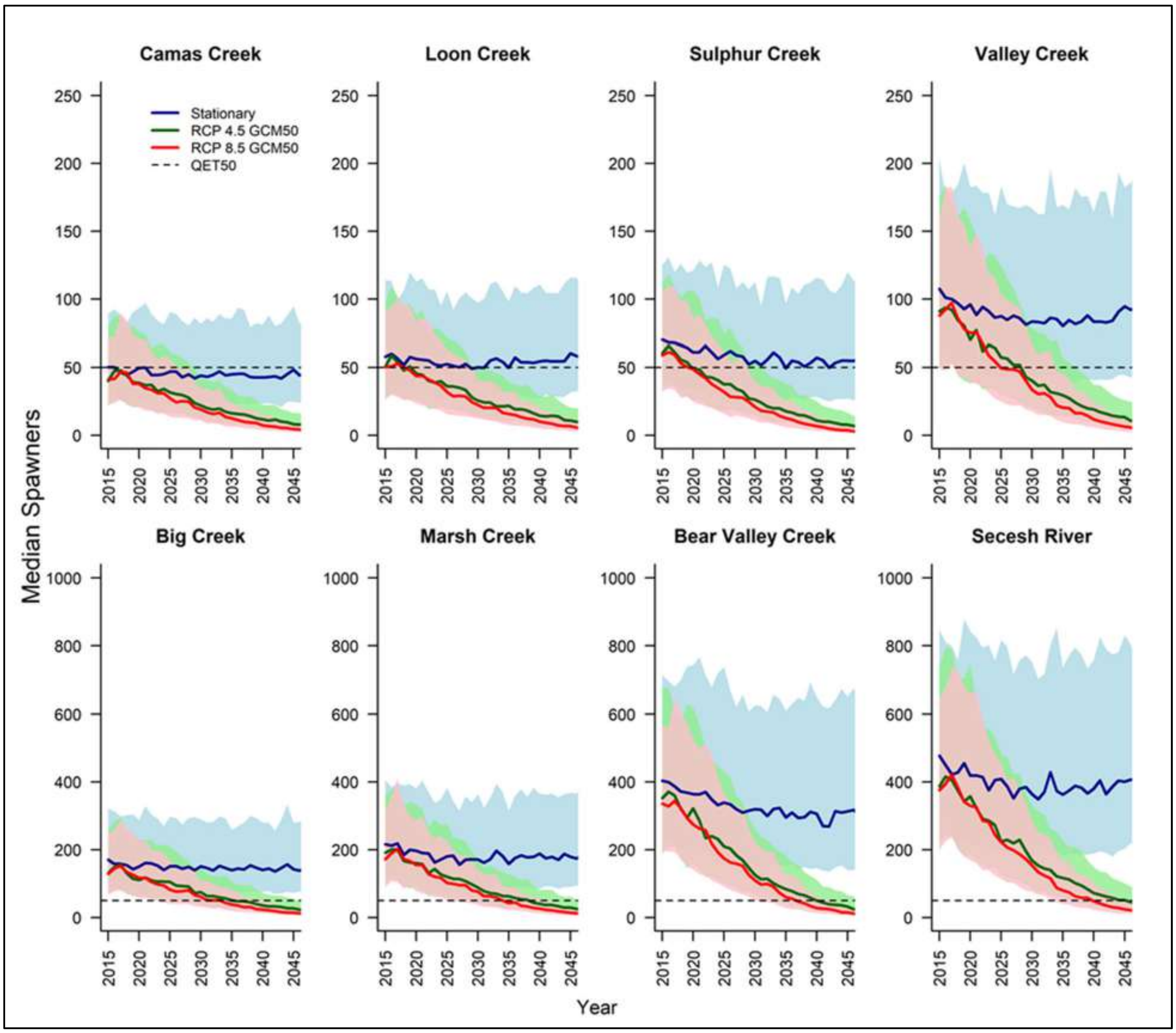


Figure 2.2-16. Time series of spawner abundance for 8 populations in three climate scenarios: blue = no trends in climate, green = trends from RCP 4.5, and red = trends from RCP 8.5. The solid lines show the median population abundance for a given year across all simulations, while the polygons show the range in abundance from the 10th to 90th quantiles across simulations. The green and red polygons overlap for the most part, but the slightly more optimistic results from the lowest quantile RCP 4.5 projections are visible in green shading.

Only the projected median geomean abundance and QET 50 estimates from the median RCP8.5 climate scenario are presented in the following tables. These results are compared to the projected estimates of median geomean abundance and QET 50 previously presented for the proposed action and proposed action plus 35 percent modelling results discussed earlier in this section, to represent the potential reductions SR spring/summer Chinook salmon populations could experience if future climate conditions manifest in freshwater and ocean habitat as current correlations suggest.

In addition to the projected median information summarized in the tables, the figures in this section also display the projected results of 25th percentile (representing a lower than median rate of climate change) and 75th percentile (representing a higher than median rate of climate change) modelling scenarios. More detailed outputs, including estimates of QET 30 (a less conservative metric than QET 50) are provided in Appendix C.

Grande Ronde River MPG

As previously noted, within the Grande Ronde River MPG, five populations have sufficient information available to support life-cycle modeling. These populations were analyzed using Model 3, (2.2.3.1.12 Life-Cycle Models). As in the previous analysis there are analyses of total spawners (hatchery and natural origin) and natural origin only presented for the Catherine Creek and Lostine River populations as both populations receive hatchery supplementation. Model results are displayed in Table 2.2-24 and in Figures 2.2-17 and 2.2-18. Table 2.2-24 summarizes the projected median geomean abundance and QET 50 probabilities under the median RCP8.5 climate scenario compared to the proposed action and proposed action plus 35 percent scenarios under historical climate conditions. Figures 2.2-17 and 2.2-18 graphically displays this information and additional “Low” and “High” RCP8.5 climate scenarios. Further detail, including estimates for the 5th and 95th percentiles is presented in Appendix C.

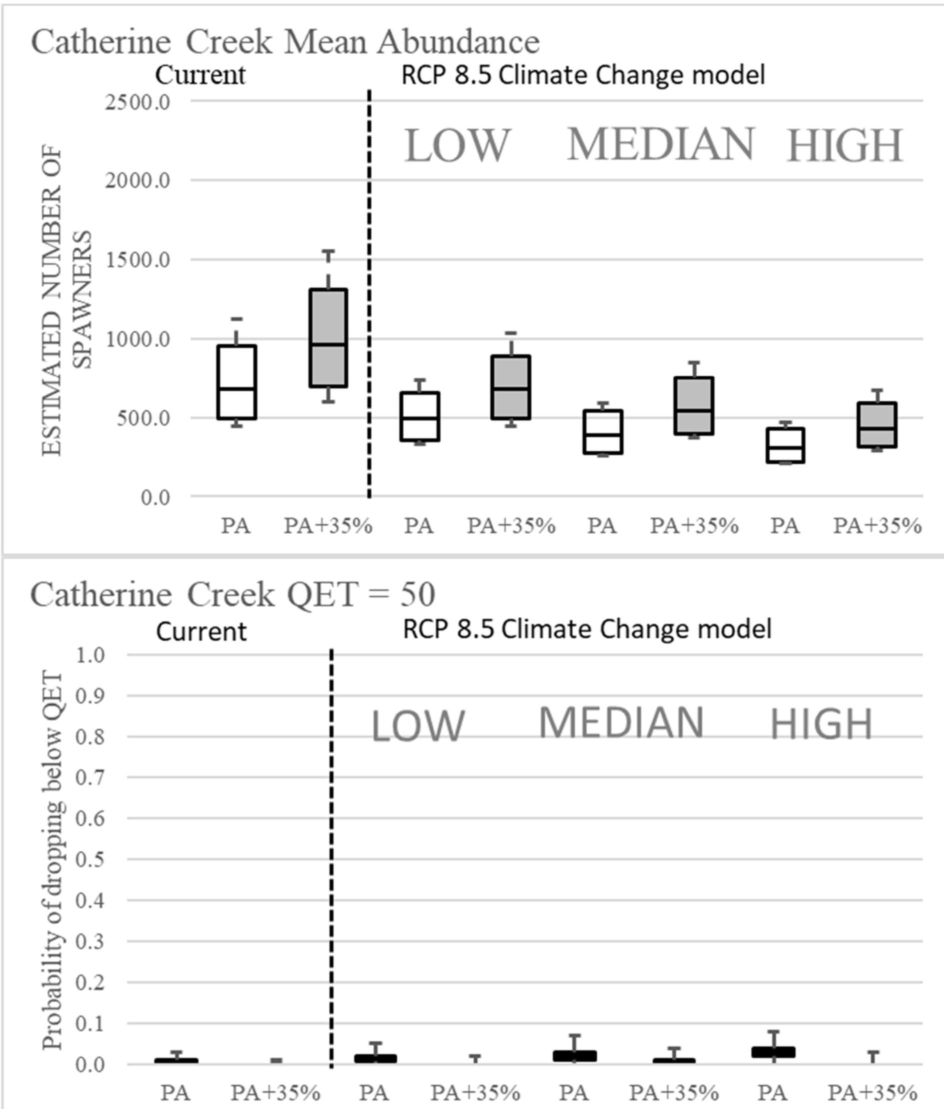
Considering only natural origin spawners, the potential median projected effects of climate change had extremely negative effects on all five populations. The life-cycle model projects that median geomean abundance of the Upper Grande Ronde River MPG populations under the median RCP8.5 climate scenario could decrease by 45 to 65 percent compared to the projection for the proposed action scenario under recent historical climate conditions. Estimates using the CSS hypothesized 35 percent productivity increase from reduced latent mortality decreased by similar amounts. The projected median abundance of hatchery supplemented populations showed smaller decreases (43-48 percent), but were still substantially affected.

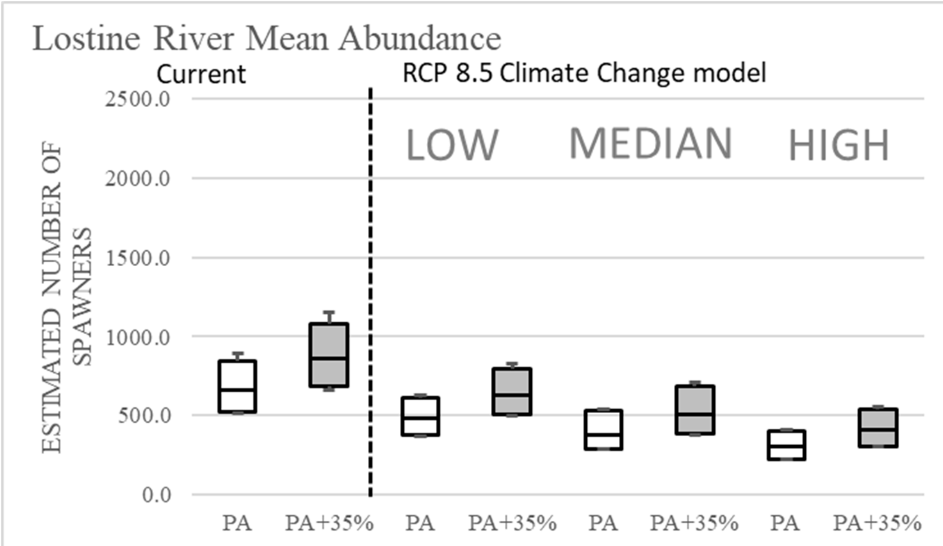
The potential projected median effects of climate change increase the probability falling below the QET 50 threshold for natural spawners in all five populations. The median probability increased to between 18 and 97 percent for the five populations under the proposed action. The addition of the CSS hypothesized 35 percent latent mortality productivity increase reduced the probability of falling below QET 50, as would be expected. The three populations supported by hatchery supplementation had substantially lower probabilities of dropping below QET 50 than populations with only natural spawners under the median RCP8.5 climate scenario.

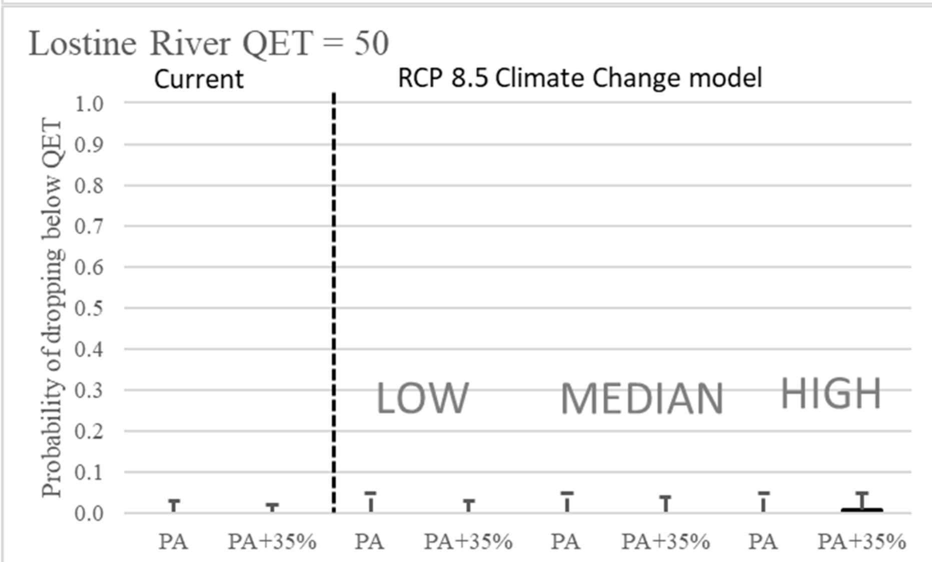
Table 2.2-24. Climate change analysis (RCP8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Grande Ronde River MPG populations of hatchery and naturally produced fish combined under the proposed action and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Median values for projected abundance under recent, historical climate conditions are provided for comparison.

Grande Ronde River MPG	Abundance						QET = 50			
Hatchery and natural origin	historic	Median	25th	75th	Change	% Change	Historic	Median	25th	75th
Catherine Creek										
Proposed Action	679	388	274	542	-292	-43.0%	0.01	0.02	0.01	0.03
Proposed Action +35%	965	543	396	753	-422	-43.8%	0.00	0.01	0.00	0.01
Lostine River										
Proposed Action	658	377	289	529	-281	-42.7%	0.00	0.00	0.00	0.00
Proposed Action +35%	858	505	384	684	-352	-41.1%	0.00	0.00	0.00	0.00
Upper Grande Ronde										
Proposed Action	567	293	212	434	-274	-48.3%	0.00	0.00	0.00	0.00
Proposed Action +35%	767	415	305	592	-352	-45.9%	0.00	0.00	0.00	0.00
Catherine Creek										
Proposed Action	313	172	122	247	-141	-45.1%	0.29	0.40	0.37	0.42
Proposed Action +35%	451	247	178	348	-203	-45.1%	0.11	0.15	0.13	0.18
Lostine River										
Proposed Action	233	123	84	188	-110	-47.3%	0.03	0.18	0.15	0.20
Proposed Action +35%	336	178	124	259	-158	-47.0%	0.01	0.05	0.04	0.06
Minam River										
Proposed Action	217	91	11	374	-126	-58.1%	0.35	0.45	0.42	0.49
Proposed Action +35%	843	331	68	934	-512	-60.7%	0.16	0.24	0.21	0.27
Upper Grande Ronde										
Proposed Action	66	39	29	52	-26	-40.2%	0.91	0.97	0.95	0.98
Proposed Action +35%	85	51	39	68	-33	-39.2%	0.74	0.90	0.88	0.91
Wenaha River										
Proposed Action	*195*	68	24	219	-127	-65.0%	0.25	0.49	0.46	0.51

Grande Ronde River MPG	Abundance						QET = 50			
Hatchery and natural origin	**historic**	**Median**	**25th**	**75th**	**Change**	**% Change**	**Historic**	**Median**	**25th**	**75th**
Proposed Action +35%	*844*	328	131	812	-516	-61.2%	0.07	0.13	0.12	0.15




Lostine River Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Lostine River QET = 50
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

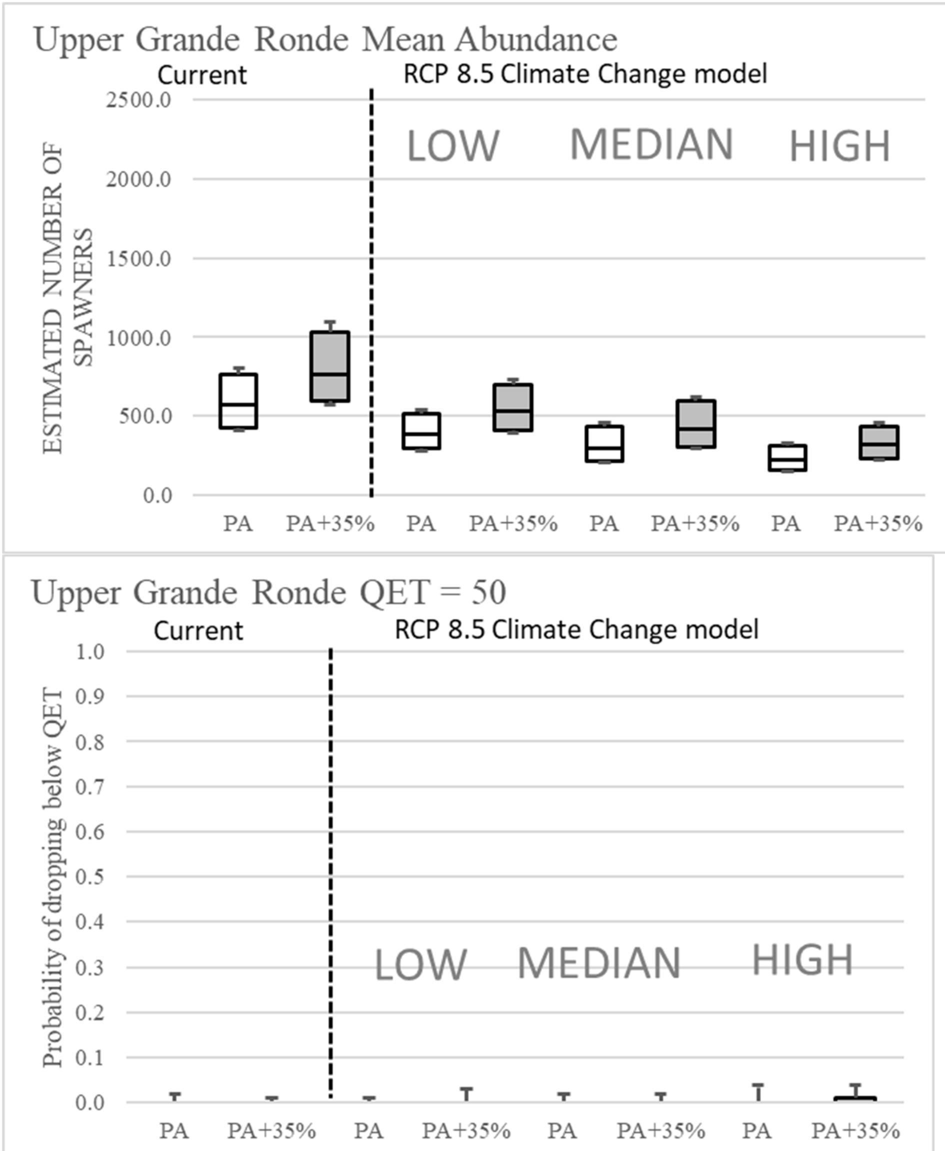
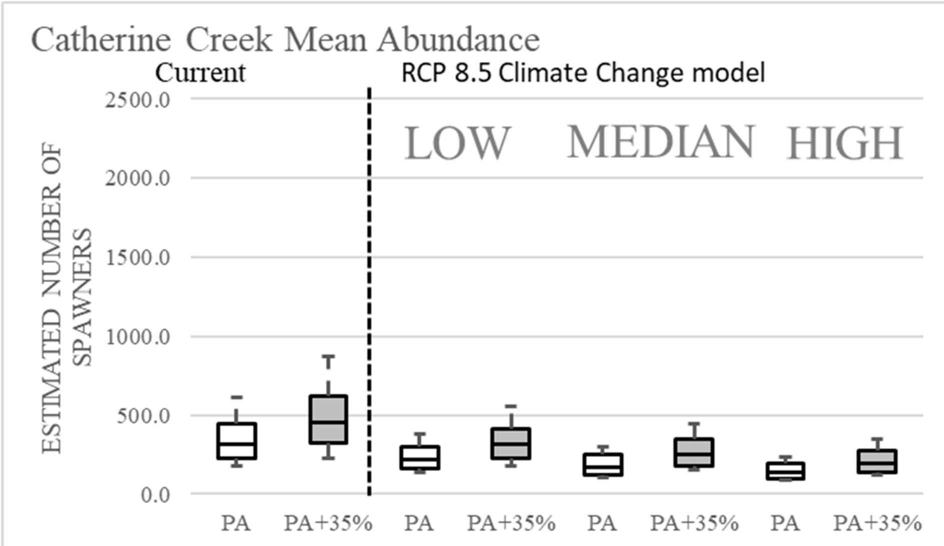
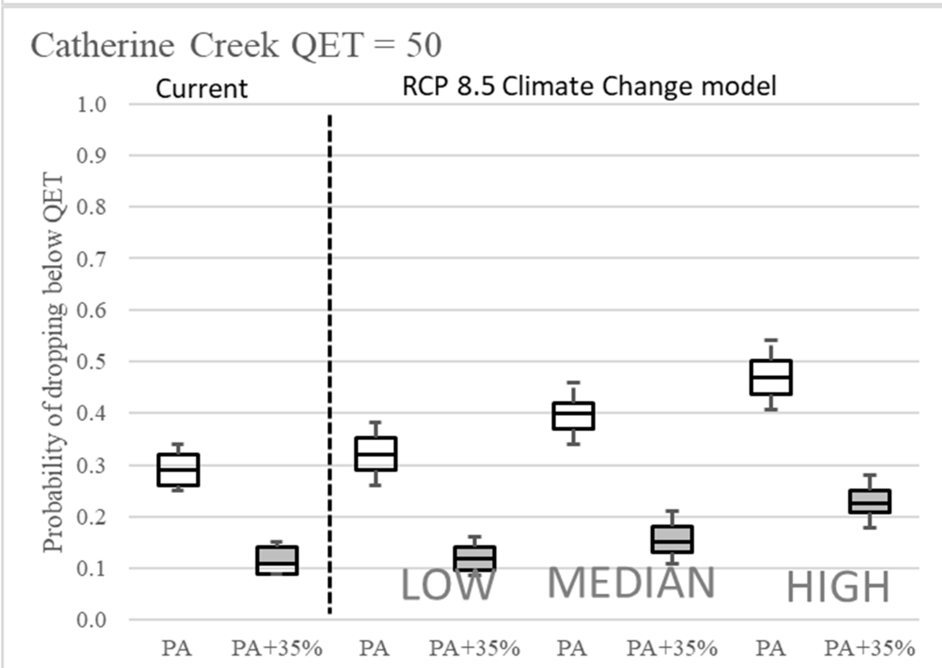
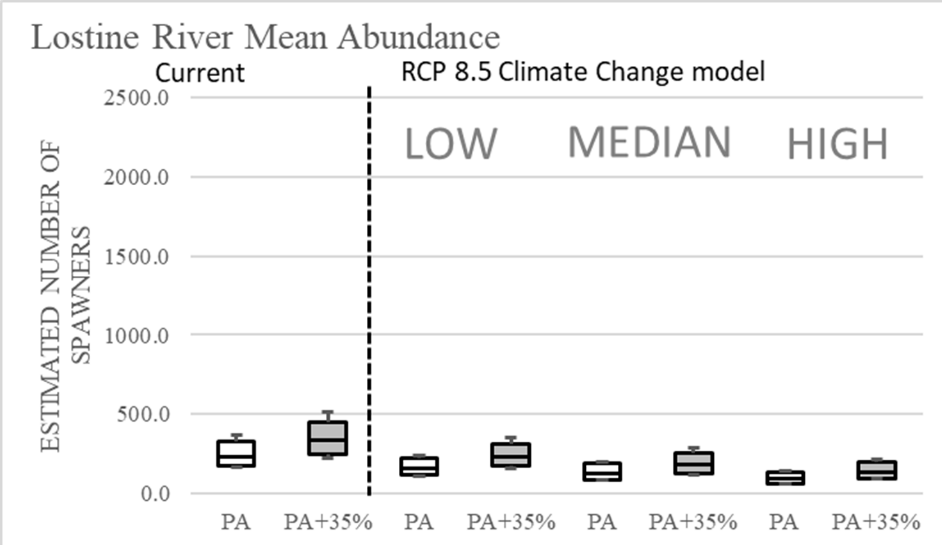
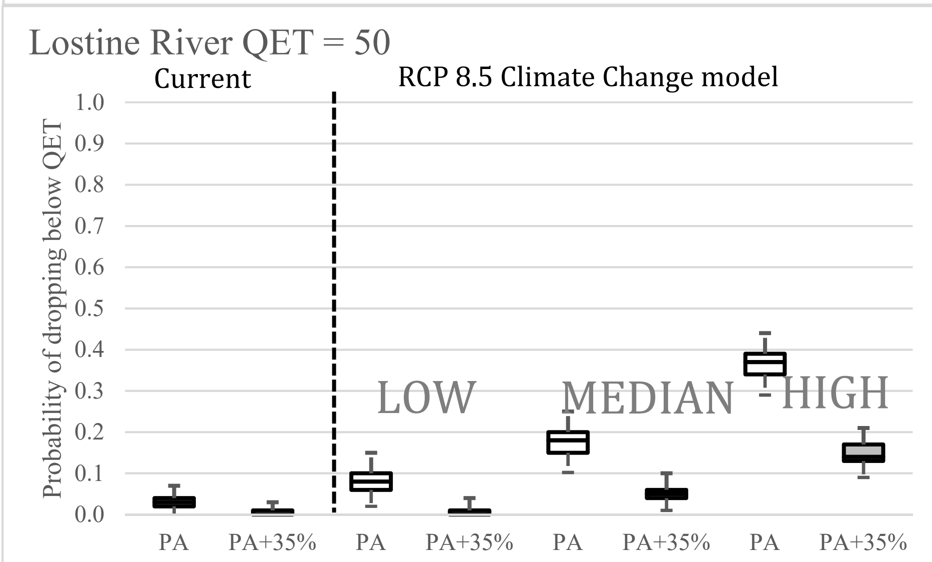


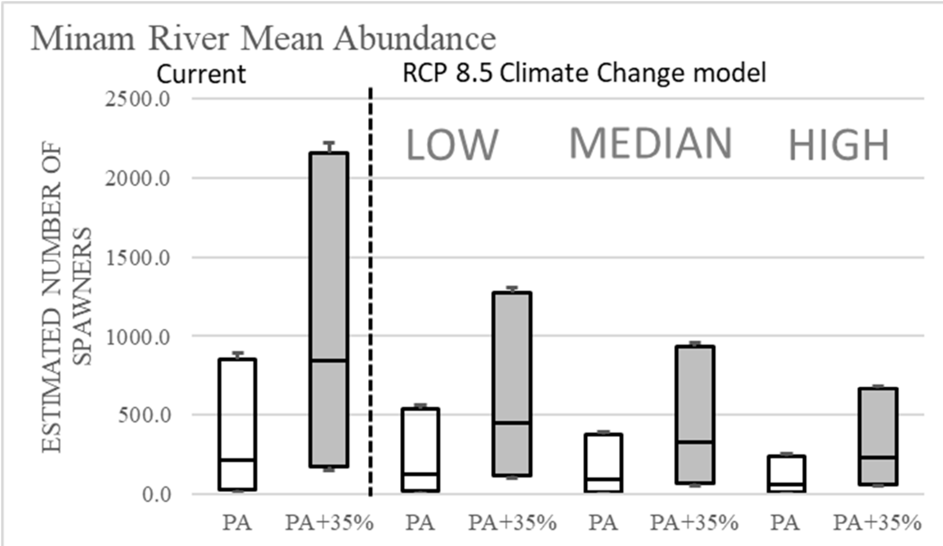
Figure 2.2-17. Climate change analysis (RCP8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 for Grande Ronde River MPG populations of hatchery and naturally produced fish in 24 years under the proposed action and assuming 35 percent increase in productivity (CSS hypothesis). Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

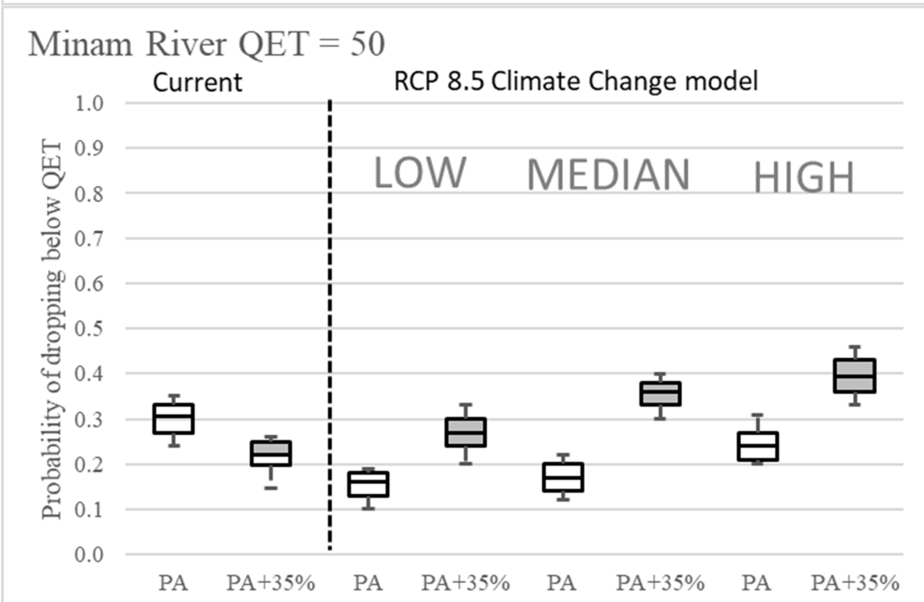

Catherine Creek Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

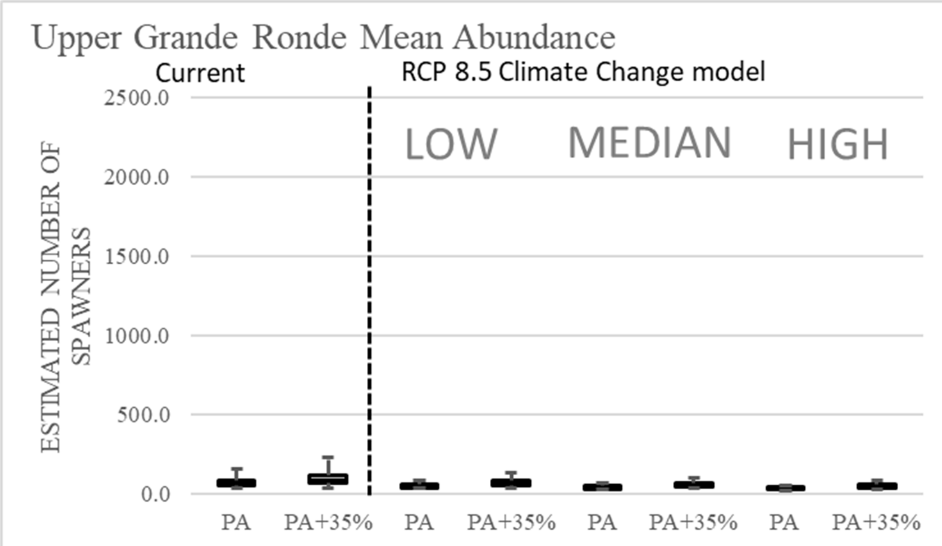

Catherine Creek QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

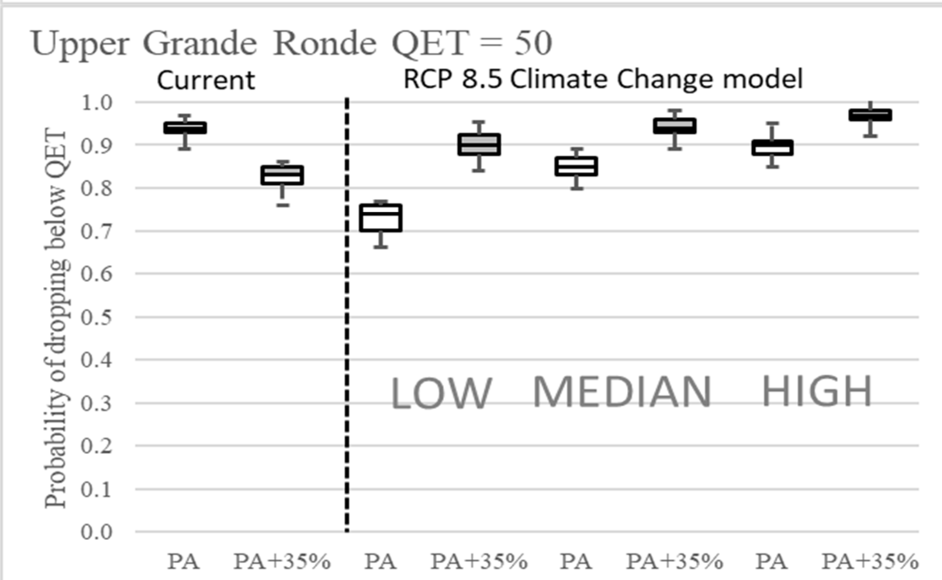

Lostine River Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Lostine River QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Minam River Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Minam River QET = 50
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Upper Grande Ronde Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Upper Grande Ronde QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

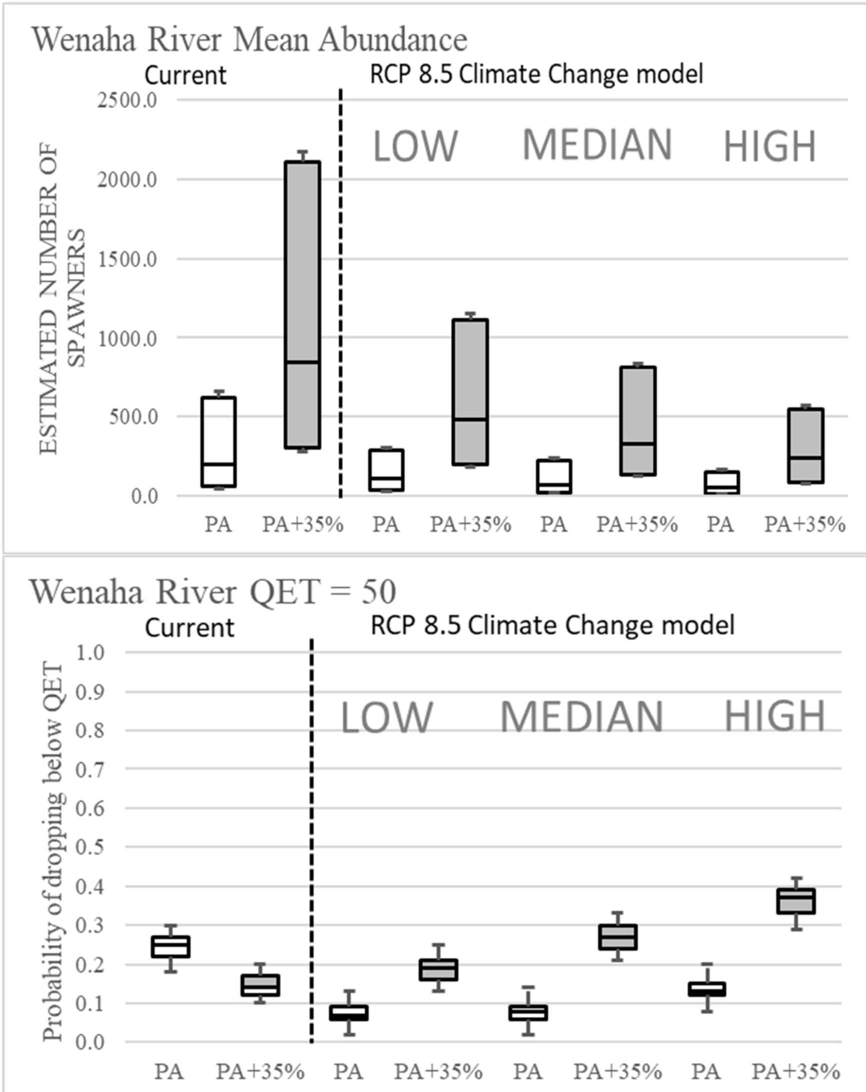


Figure 2.2-18. Climate change analysis (RCP8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 for Grande Ronde River MPG populations of naturally produced fish in 24 years under the proposed action and assuming 35 percent increase in productivity (CSS hypothesis). Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

South Fork Salmon River MPG

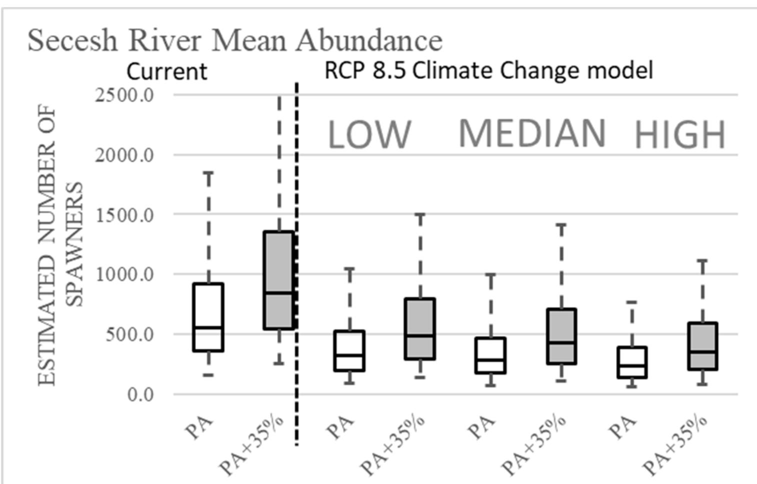
As previously noted, within the South Fork Salmon River MPG, the only wild population, Secesh River population was modeled. This population was analyzed using Model 2 (2.2.3.1.12 Life-Cycle Models). Table 2.2-25 summarizes the projected median geomean abundance and QET 50 probabilities under the median RCP8.5 climate scenario compared to the proposed action and proposed action plus 35 percent scenarios. There is little hatchery influence in this ESU so the analysis only includes wild fish. Figure 2.2-19 graphically displays this information and additional “Low” and “High” RCP8.5 climate scenarios. Further detail, including estimates for the low, median, and high predictions of RCP4.5 are presented in Appendix C.

The life-cycle model projects that median geomean abundance of the Secesh River population under the median RCP8.5 climate scenario could decrease by nearly 49 percent compared to the projection for the proposed action without the influence of future climate change; and the median probability of the population falling below the QET 50 threshold would increase from three to eight percent (Table 2.2-25). The median geomean abundance also decreases about 49 percent compared to the proposed action plus 35 percent scenario (CSS hypothesis) without the climate change influence; but the median probability of the population falling below the QET 50 threshold did not change.

Figure 2.2-19 illustrates the substantial decline in projected geomean abundance and increasing probability of falling below the QET 50 threshold in response to increasingly negative RCP8.5 climate emission scenarios for the Secesh population, compared to the proposed action and proposed action plus 35 percent scenarios assuming current climate conditions are maintained into the future.

Table 2.2-25. Climate change analysis (RCP8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for South Fork Salmon MPG populations of naturally produced fish under the proposed action and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Median values for projected abundance under recent, historical climate conditions are provided for comparison.

South Fork Salmon MPG	Abundance							QET = 50		
Natural origin	Historic	Median	25th	75th	Change	% Change	Historic	Median	25th	75th
Secesh River										
Proposed Action	556	286	173	471	-270	-48.6%	0.03	0.08	0.07	0.10
Proposed action + 35%	840	426	258	707	-414	-49.3%	0.04	0.04	0.03	0.05



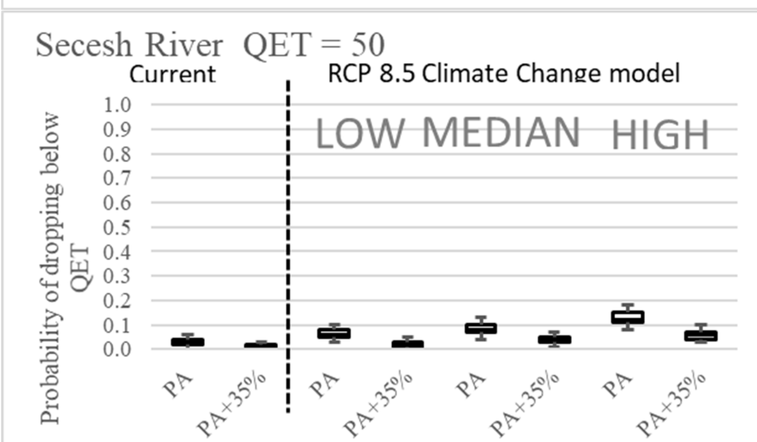


Figure 2.2-19. Climate change analysis (RCP8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 for the Secesh River population (South Fork Salmon MPG) of naturally produced fish in 24 years under the proposed action and assuming 35 percent increase in productivity (CSS hypothesis). Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

Middle Fork Salmon River MPG

As previously noted, within the Middle Fork Salmon River MPG, six populations have sufficient information available to support life-cycle modeling. These populations were analyzed using Model 2 (2.2.3.1.12 Life-Cycle Models). Model results are displayed in Table 2.2-26 and in Figure 2.2-20. There is little hatchery influence in this ESU so the analysis only includes wild fish. Table 2.2-26 summarizes the projected median geomean abundance and QET 50 probabilities under the median RCP8.5 climate emission scenario compared to the proposed action and proposed action plus 35 percent scenario assuming current climate conditions will be maintained into the future. Figure 2.2.-20 graphically displays this information and additional "Low" and "High" RCP8.5 climate emission scenarios. Further detail, including estimates for the 5th and 95th percentiles is presented in Appendix C.

The potential projected effects of climate change had extremely negative effects on all six populations. The life- cycle model projects that median geomean abundance of the Middle Fork Salmon River MPG population under the median RCP8.5 climate emission scenario could decrease by 71 to 85 percent compared to the projection under historical climate conditions for the proposed action. The median geomean abundance decreased 73 to 86 percent compared to the proposed action plus 35 percent scenario (CSS hypothesis).

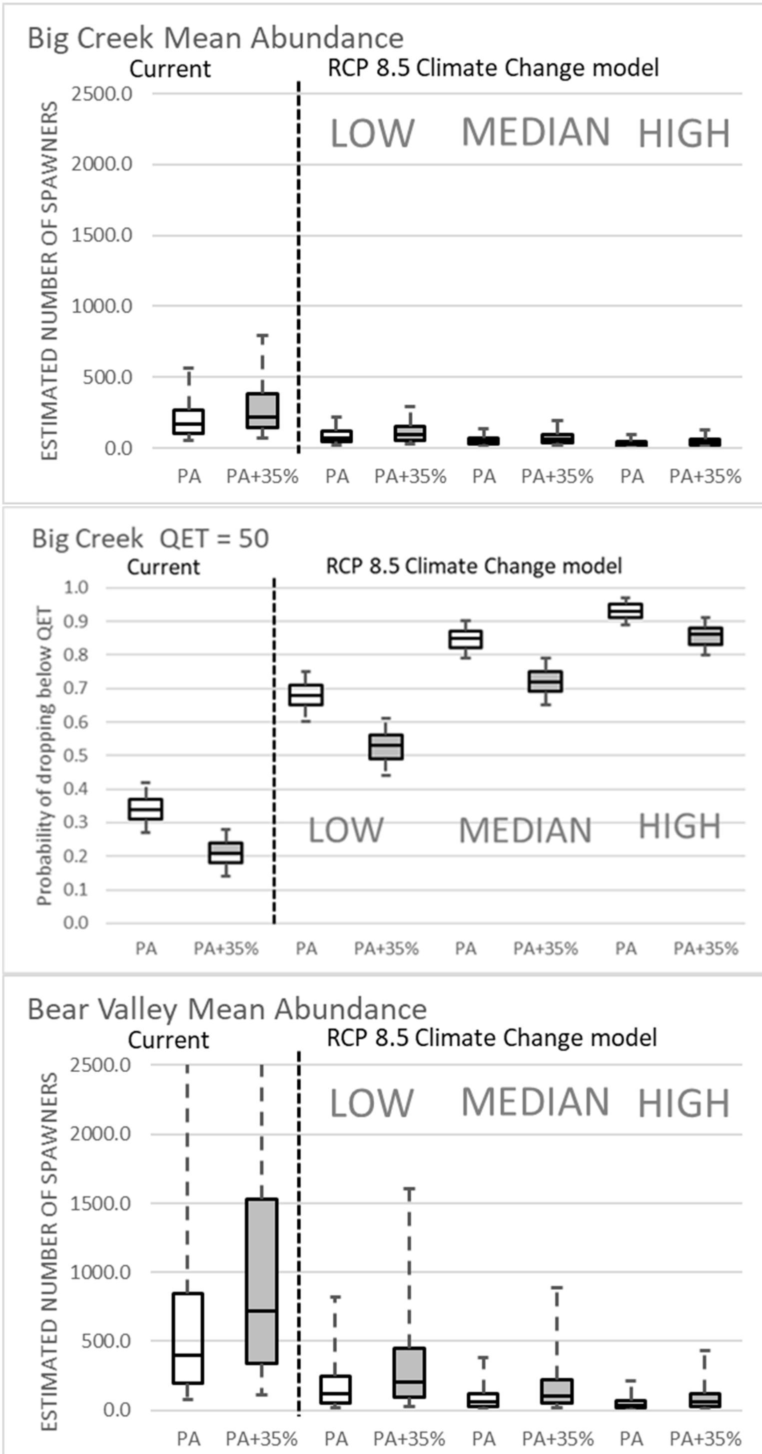
The median RCP8.5 modelling projected that the median geomean abundance of the smaller populations (Sulphur, Camas and Loon Creek) would decrease to 17 adults or less with the proposed action, and 22 or fewer fish with the proposed action plus 35 percent scenario; and that the larger populations (Big, Bear Valley, and Marsh Creeks) would decrease to 44 to 60 adults with the proposed action, and 59 to 101 adults with the proposed action plus 35 percent scenarios.

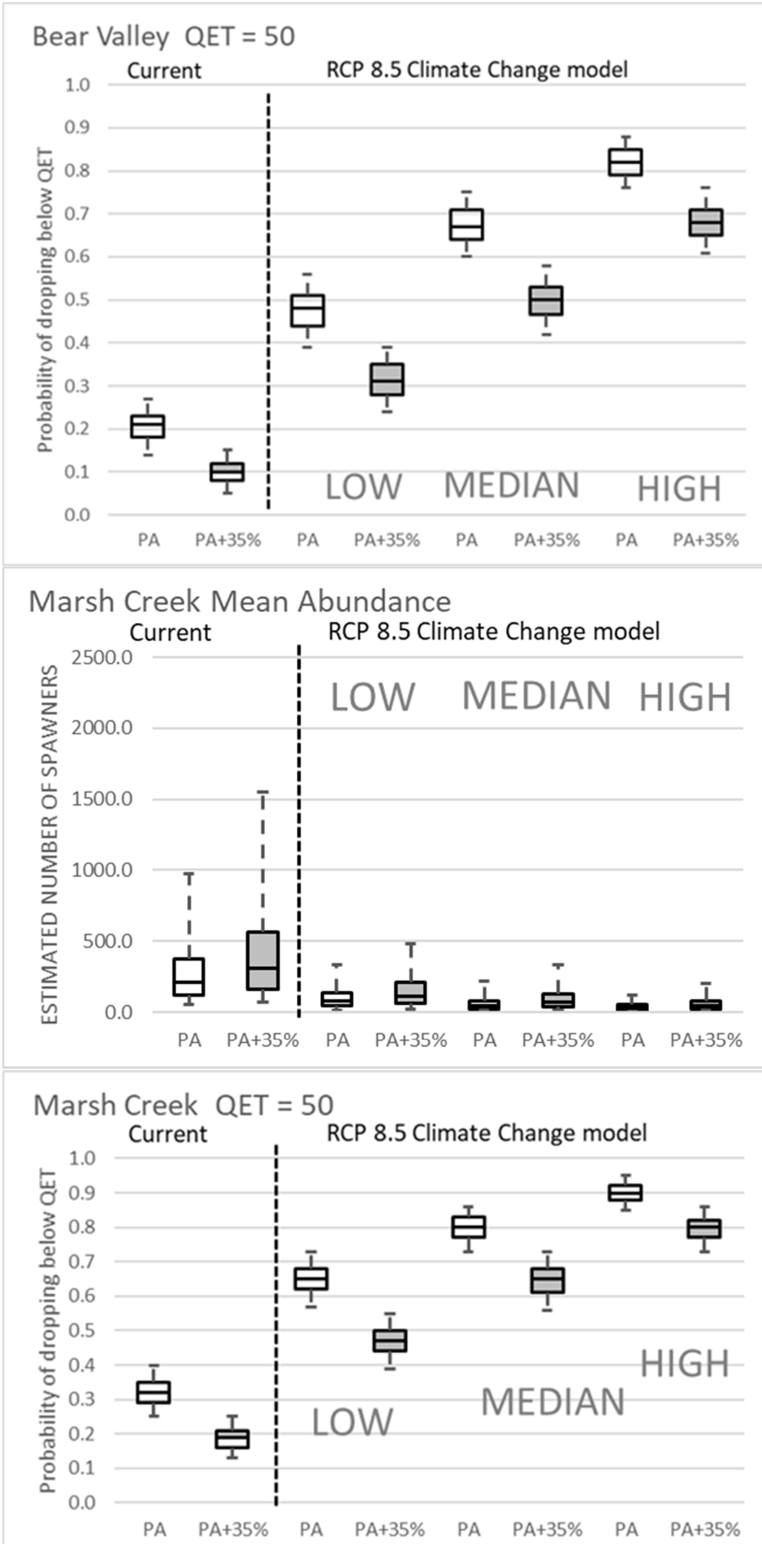
The potential projected effects of climate change substantially increase the probability of falling below the QET = 50 threshold for all six populations. The median probability increased to between 93 and 100 percent for the three smaller populations under either the proposed action or proposed action plus 35 percent scenarios. The median probabilities also increased substantially for the larger populations, ranging from 67 to 85 percent with the proposed action scenario, and from 50 to 72 percent with the proposed action plus 35 percent scenario.

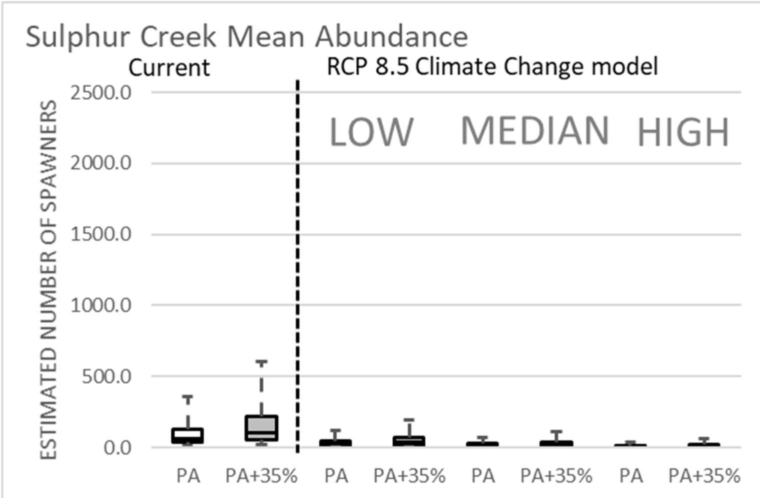
Figure 2.2-20 illustrates the substantial decline in projected median abundance and increasing probability of falling below the QET 50 threshold in response to increasingly negative RCP8.5 climate emission scenarios for each of the six Middle Fork Salmon River MPG populations, compared to the proposed action and proposed action plus 35 percent scenarios assuming the current climate conditions are maintained into the future.

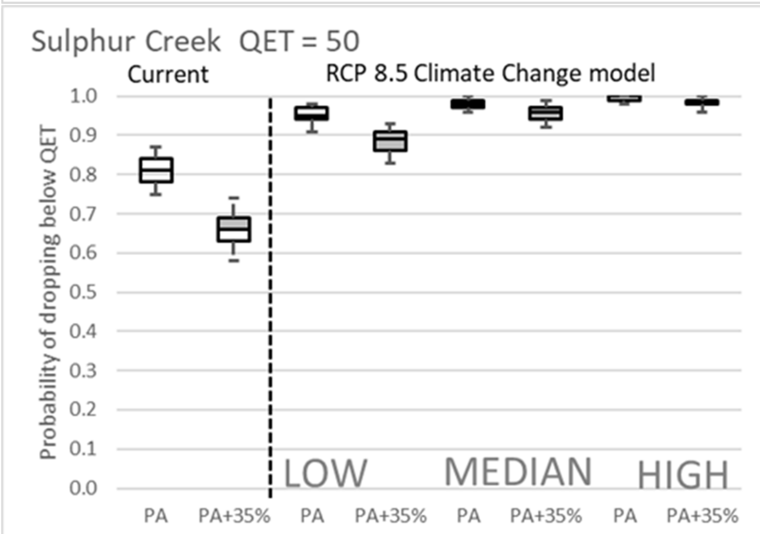
Table 2.2-26. Climate change analysis (RCP8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Middle Fork Salmon MPG populations of naturally produced fish under the proposed action and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Median values for projected abundance assuming current climate conditions are maintained are provided for comparison.

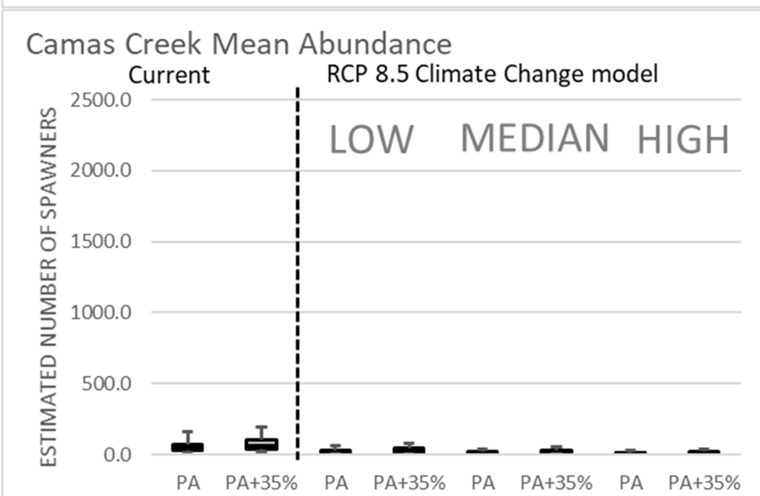
Middle Fork Salmon MPG	Abundance						QET = 50			
Population	Historic climate	Median	25th	75th	change	% Change	Historic climate	Median	25th	75th
Big Creek										
Proposed Action	166	44	27	68	-122	-73.5%	0.34	0.85	0.82	0.87
Proposed action + 35%	222	59	35.0	95.	-163	-73.4%	0.21	0.72	0.69	0.75
Bear Valley Creek										
Proposed Action	399	60	29	124.0	-339	-85.0%	0.21	0.67	0.64	0.71
Proposed action + 35%	718	101	51	224	-617	-85.9%	0.10	0.5	0.47	0.53
Marsh Creek										
Proposed Action	212	46	25	82	-166	-78.3%	0.35	0.8	0.77	0.83
Proposed action + 35%	306	72	38	127	-234	-76.5%	0.21	0.65	0.61	0.68
Sulphur Creek										
Proposed Action	66	13	6	26	-53	-80.3%	0.84	0.98	0.97	0.99
Proposed action + 35%	106	21	9	38	-85	-80.2%	0.69	0.96	0.94	0.97
Camas Creek										
Proposed Action	46	12	7	20	-34	-73.9%	0.93	0.93	0.92	1
Proposed action + 35%	63	17	10	27	-46	-73.0%	0.85	0.85	0.82	1
Loon Creek										
Proposed Action	59	17	10	26	-42.	-71.2%	0.87	1	0.99	1
Proposed action + 35%	80	22	14	36	-58	-72.5%	0.75	0.98	0.97	0.99


Big Creek Mean Abundance
Current
RCP 8.5 Climate Change model
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%
Big Creek QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%
Bear Valley Mean Abundance
Current
RCP 8.5 Climate Change model
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Bear Valley QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%
Marsh Creek Mean Abundance
Current
RCP 8.5 Climate Change model
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%
Marsh Creek QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
HIGH
MEDIAN
LOW
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Sulphur Creek Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Sulphur Creek QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Camas Creek Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

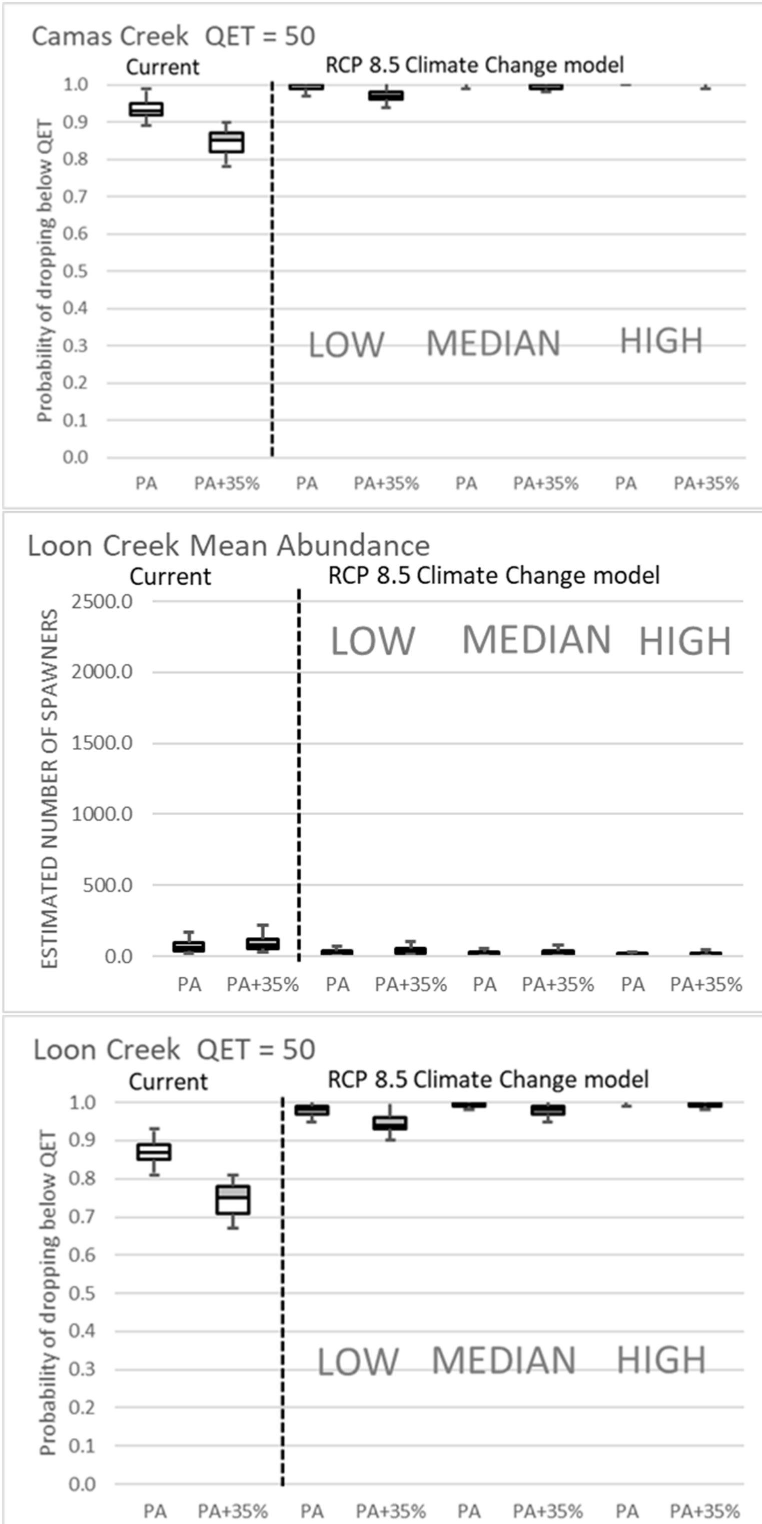


Figure 2.2-20. Climate change analysis (RCP8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 for Middle Fork Salmon MPG populations of naturally produced fish in 24 years under the proposed action and assuming 35 percent increase in productivity (CSS hypothesis). Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

Upper Salmon River MPG

As previously noted, within the Upper Salmon River MPG, seven populations have sufficient information available to support life-cycle modeling. These populations were analyzed using Model 1, excepting Valley Creek which was modelled using both Model 1 and Model 2 (2.2.3.1.12 Life-Cycle Models). Model results are displayed in Table 2.2-27 and in Figures 2.2-21a and 2.2-21b. Table 2.2-27 summarizes the projected median geomean abundance and QET 50 probabilities under the median RCP8.5 climate emission scenario compared to the proposed action and proposed action plus 35 percent scenarios assuming current climate conditions are maintained. Figures 2.2-21a and 2.2-21b graphically displays this information. Further detail, including estimates for the 5th and 95th percentiles is presented in Appendix C.

The potential projected effects of climate change had extremely negative effects on all six populations. The life-cycle model projects that median geomean abundance of the Upper Salmon River MPG populations under the median RCP8.5 climate emission scenario could decrease by 28 to 74 percent compared to the projection for the proposed action scenario and the proposed action plus 35 percent scenario (CSS hypothesis).

The median RCP8.5 modelling projected that the median geomean abundance of the smaller populations (East Fork, North Fork, Panther, Valley Creek, Yankee Fork, and Lemhi) would decrease to 39 adults or less with the proposed action, and 94 or fewer fish with the proposed action plus 35 percent scenario. The projected geomean abundance of the larger populations (Pahsimeroi and Upper Mainstem) would decrease to 94 and 163 adults, respectively, with the proposed action scenario, and to 142 to 262 adults, respectively, with the proposed action plus 35 percent scenario.

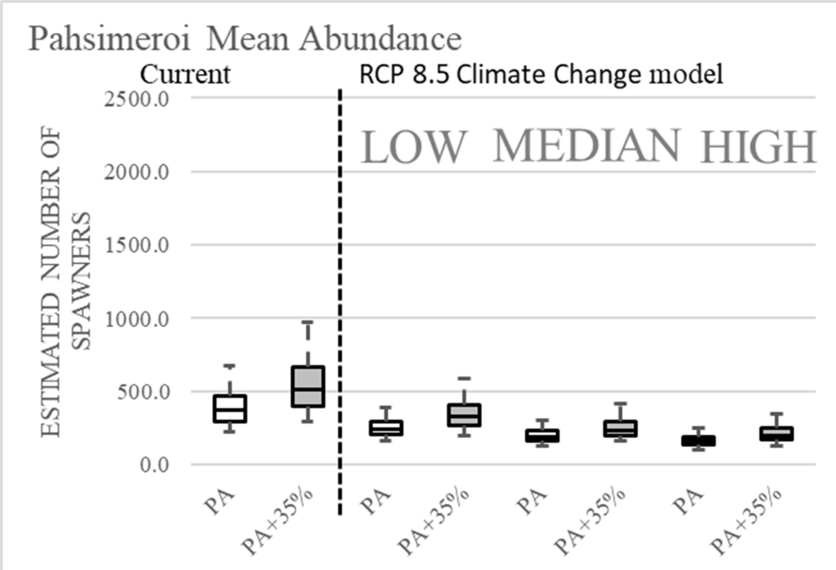
The potential projected effects of climate change substantially increased the probability falling below the QET 50 threshold for naturally produced fish in all six populations. The median probability increased to between 80 and 100 percent for the five smaller populations under either the proposed action or proposed action plus 35 percent scenarios. The median probabilities also increased substantially for the larger Pahsimeroi and Upper Mainstem populations—from 1 percent to 9 percent, with the proposed action scenario, and from 0 to 2 percent, with the proposed action plus 35 percent scenario. In contrast, the probability of falling below QET 50 for the hatchery supplemented Pahsimeroi and the Upper Mainstem Salmon populations remains 0.00 including both hatchery and naturally produce adults.

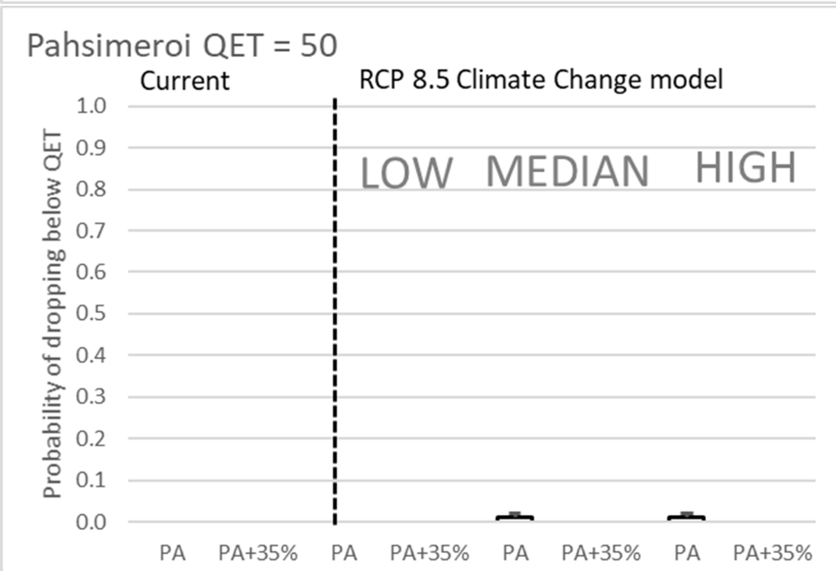
Figures 2.2-21a and 2.2-21b illustrates the substantial decline in projected median abundance and increasing probability of falling below the QET 50 threshold in response to increasingly negative RCP8.5 outputs for each of the seven Upper Salmon River MPG populations, compared to the proposed action and proposed action plus 35 percent scenarios assuming current climate conditions continue into the future.

Table 2.2-27. Climate change analysis (RCP8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for Upper Salmon MPG populations of Hatchery and naturally produced and naturally produced fish under the proposed action and assuming a 35 percent increase in survival resulting from CSS hypothesized reductions in latent mortality. Median values for projected abundance under recent, historical climate conditions are provided for comparison.

Upper Salmon MPG	Abundance						QET = 50			
Hatchery and natural spawners	Historic	Median	25th	75th	Change	% Change	Historic	25th	Median	75th
Pahsimeroi										
Proposed Action	295	191	164	229	-104	-35.1%	0.00	0.00	0.01	0.01
Proposed Action +35%	401	234	198	290	-167	-41.7%	0.00	0.00	0.00	0.00
Upper Mainstem Salmon										
Proposed Action	559	227	180	289	-332	-59.4%	0.00	0.00	0.00	0.00
Proposed Action +35%	785	326	254	423	-459	-58.5%	0.00	0.00	0.00	0.00
East Fork Salmon										
Proposed Action	135	39	24	62	-96	-71.2%	0.28	0.80	0.78	0.83
Proposed Action +35%	292	94	60	133	-199	-68.0%	0.05	0.33	0.30	0.36
North Fork Salmon										
Proposed Action	25	7	4	11	-18	-72.4%	0.94	1.00	1.00	1.00
Proposed Action +35%	64	19	12	29	-45	-70.0%	0.65	0.98	0.97	0.99
Panther Creek	0									
Proposed Action	78	37	30	46	-41	-52.3%	0.62	0.98	0.97	0.99
Proposed Action +35%	108	49	39	63	-58	-54.1%	0.27	0.86	0.85	0.88
Valley Creek										
Proposed Action	35	9	6	16	-26	-73.5%	0.85	1.00	1.00	1.00
Proposed Action +35%	88	25	14	41	-63	-71.4%	0.46	0.94	0.93	0.96
Valley Creek (2)										

Upper Salmon MPG	Abundance						QET = 50			
Hatchery and natural spawners	**Historic**	**Median**	**25th**	**75th**	**Change**	**% Change**	**Historic**	**25th**	**Median**	**75th**
Proposed Action	69	94	63	145	25	36.2%	0.67	0.99	0.98	0.99
Proposed Action +35%	97	69	44	110	-28	-28.9%	0.30	0.86	0.84	0.88
Yankee Fork										
Proposed Action	74	34	26	42	-40	-54.4%	0.35	0.75	0.73	0.78
Proposed Action +35%	106	47	36	61	-59	-55.3%	0.05	0.25	0.22	0.28
Lemhi										
Proposed Action	87	22	12	40	-65	-74.2%	0.18	0.55	0.51	0.58
Proposed Action +35%	246	74	42	113	-172	-69.8%	0.06	0.20	0.18	0.23
Pahsimeroi										
Proposed Action	266	94	67	134	-172	-64.7%	0.01	0.09	0.07	0.11
Proposed Action +35%	404	141	103	198	-263	-65.1%	0.00	0.02	0.01	0.02
Upper Mainstem Salmon										
Proposed Action	478	163	112	224	-315	-65.9%	0.01	0.09	0.11	0.14
Proposed Action +35%	697	262	190	356	-435	-62.4%	0.00	0.02	0.02	0.04


Pahsimeroi Mean Abundance
Current
RCP 8.5 Climate Change model
LOW MEDIAN HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Pahsimeroi QET = 50
Current
RCP 8.5 Climate Change model
LOW MEDIAN HIGH
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

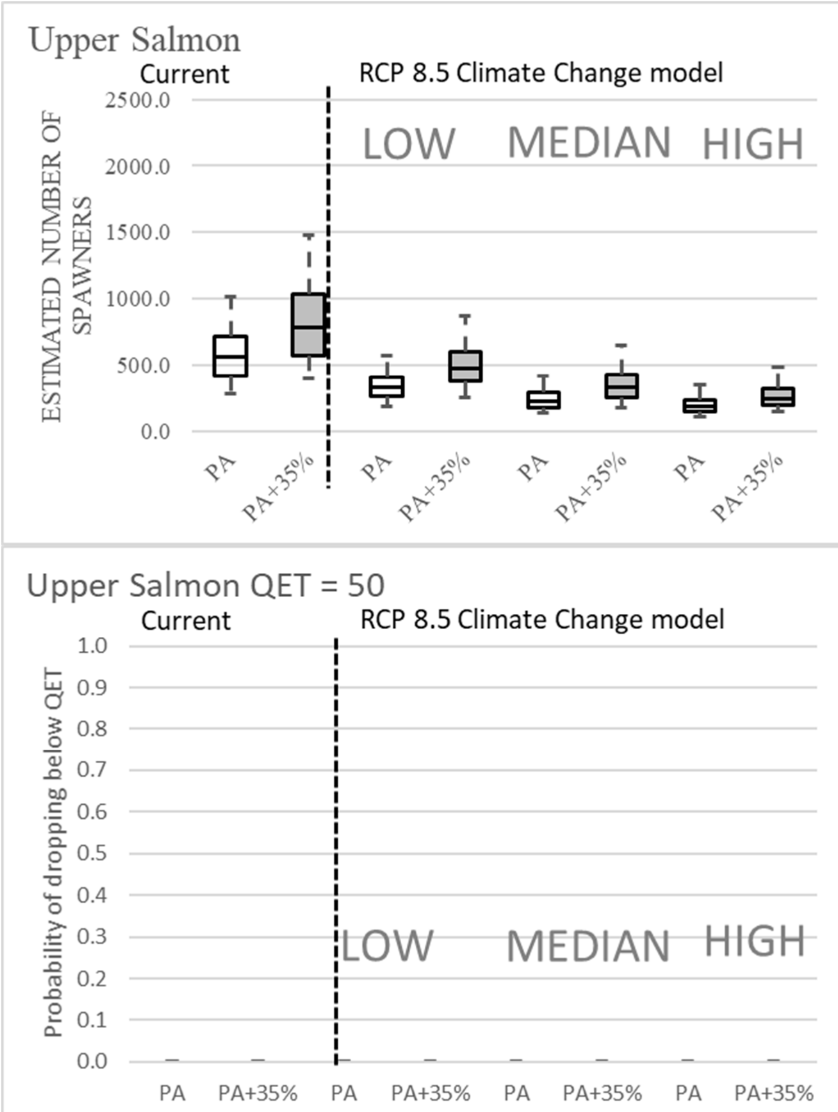
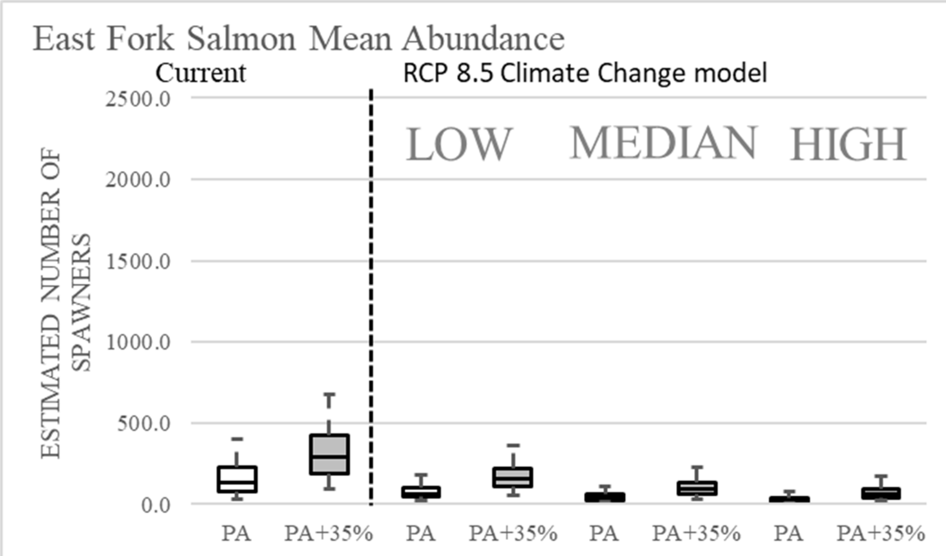
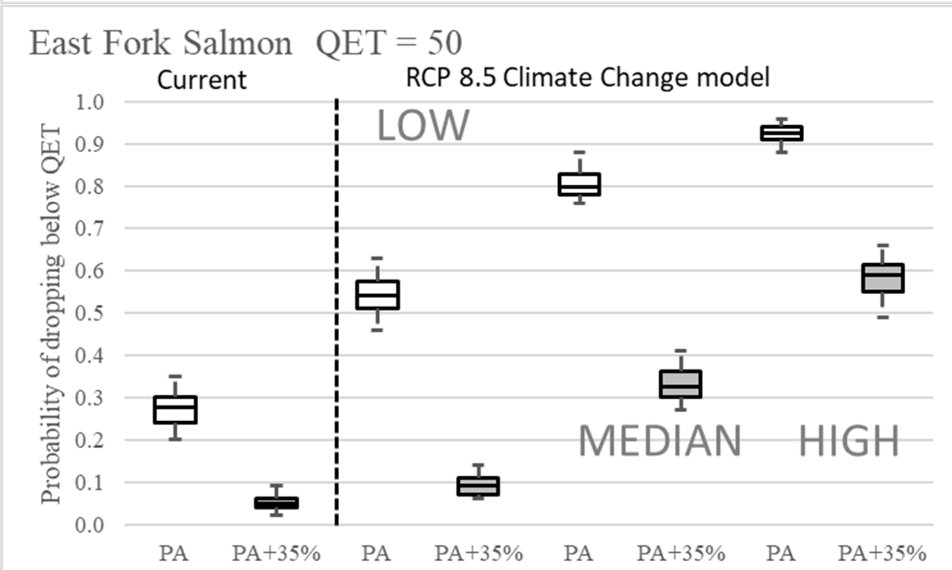
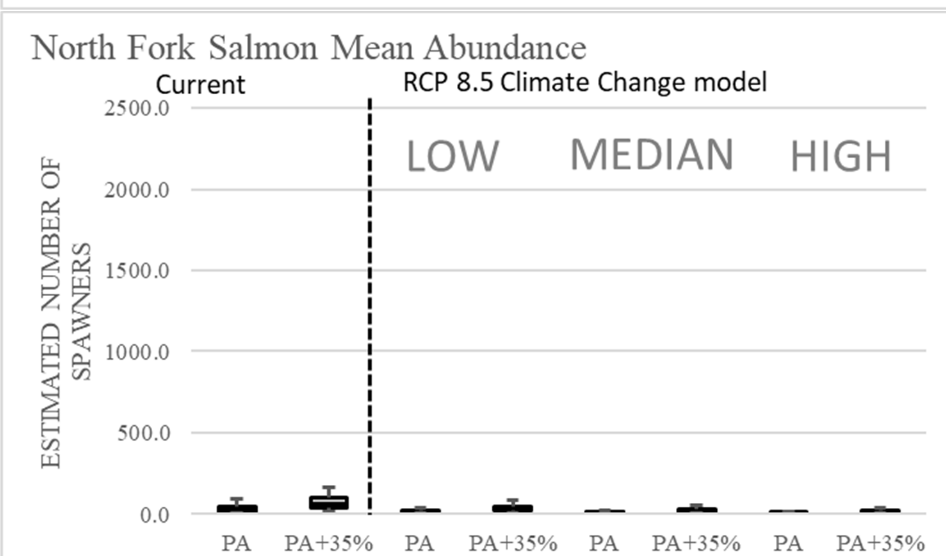
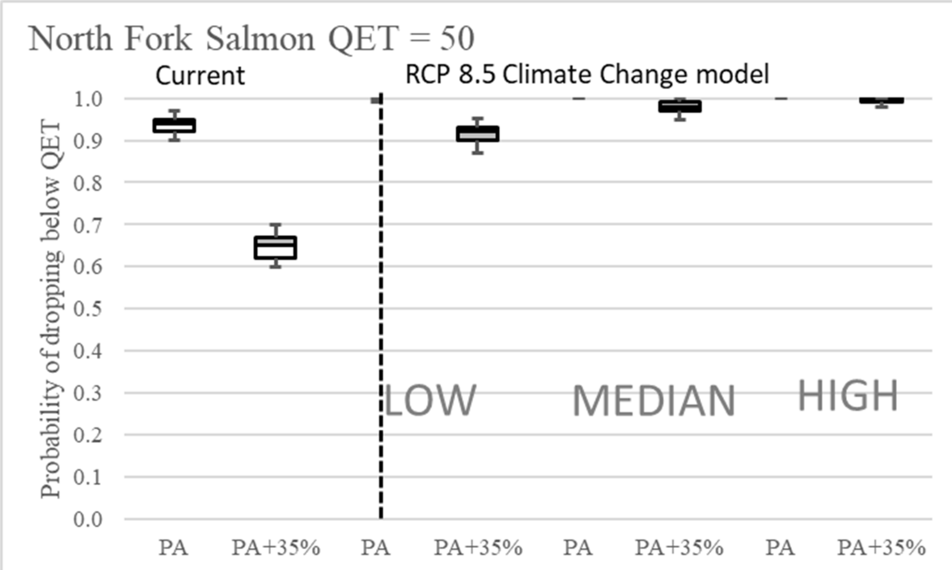


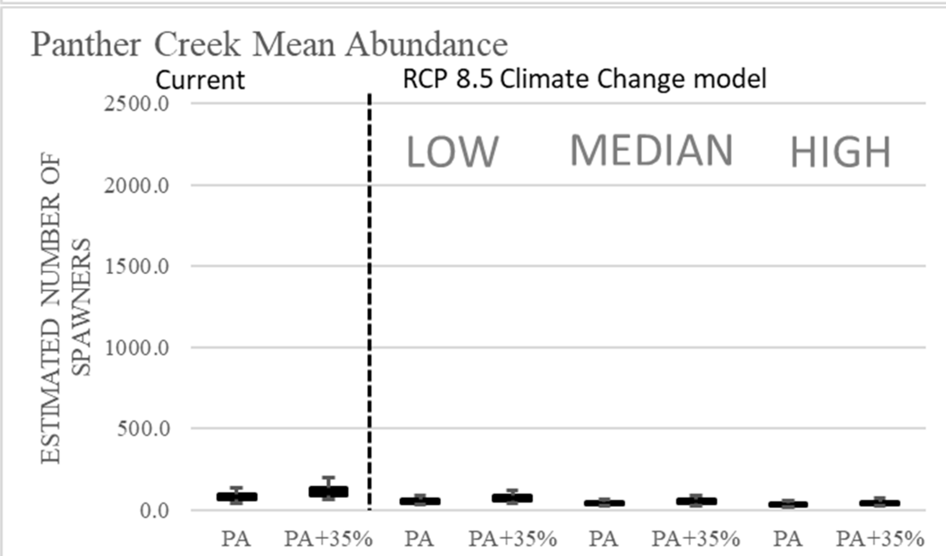
Figure 2.2-21a. Climate change analysis (RCP 8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 for Upper Salmon MPG populations of naturally produced fish in 24 years under the proposed action and assuming 35 percent increase in productivity (CSS hypothesis). Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

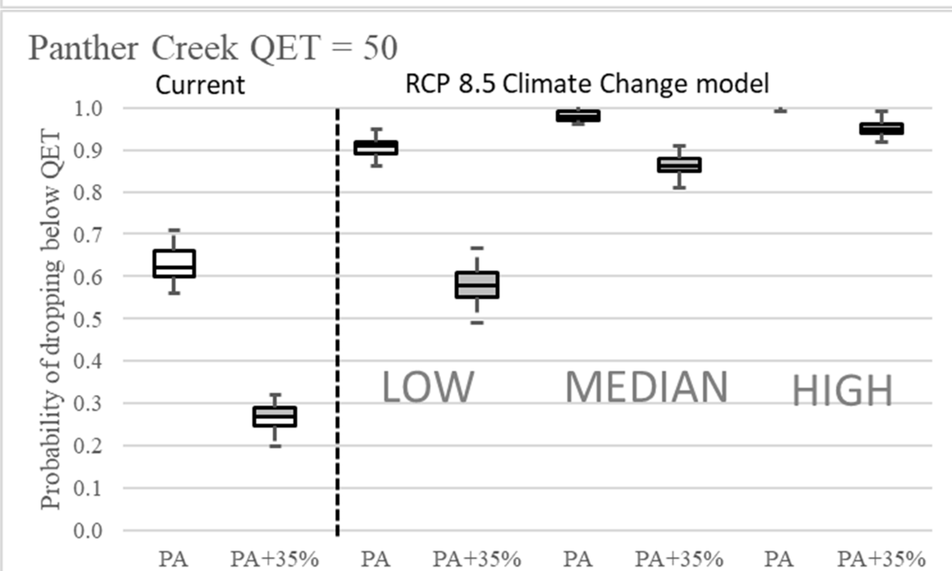

East Fork Salmon Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

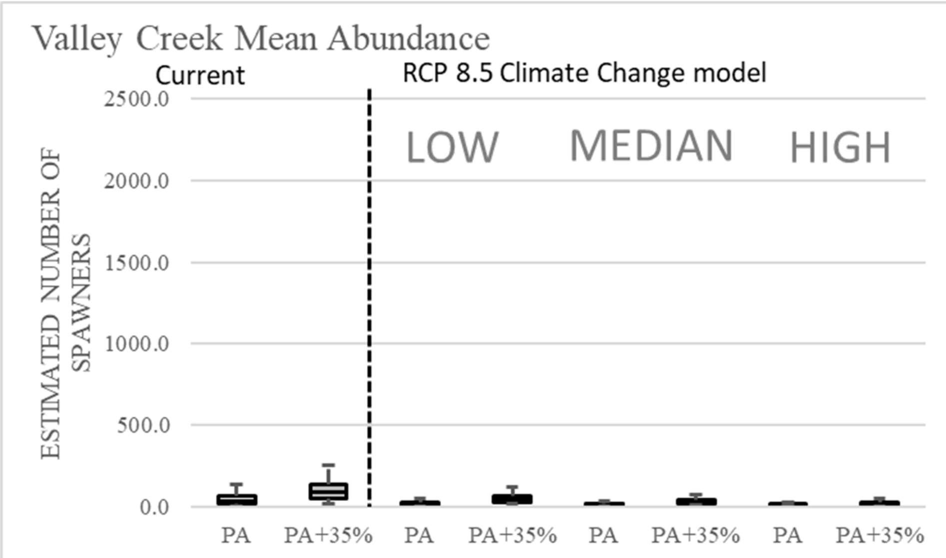

East Fork Salmon QET = 50
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

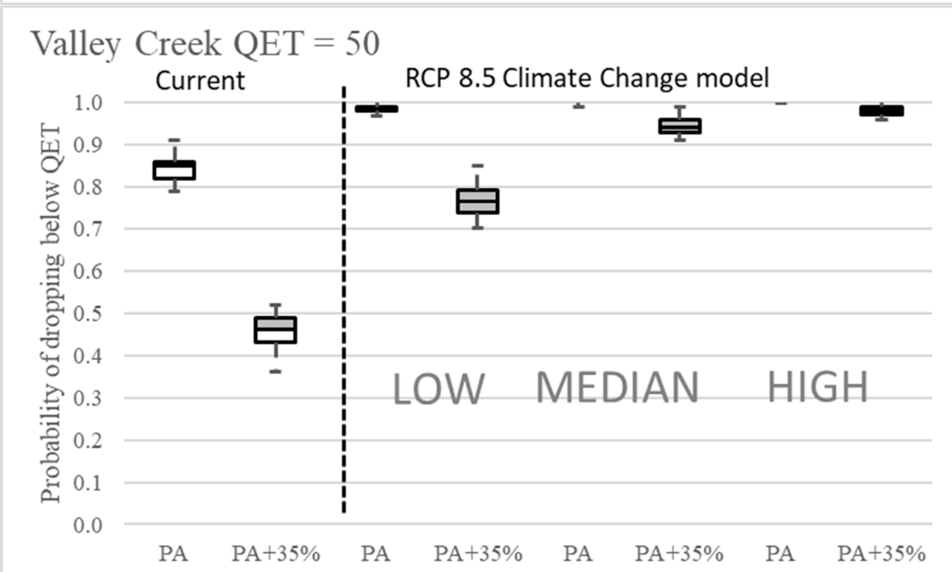

North Fork Salmon Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

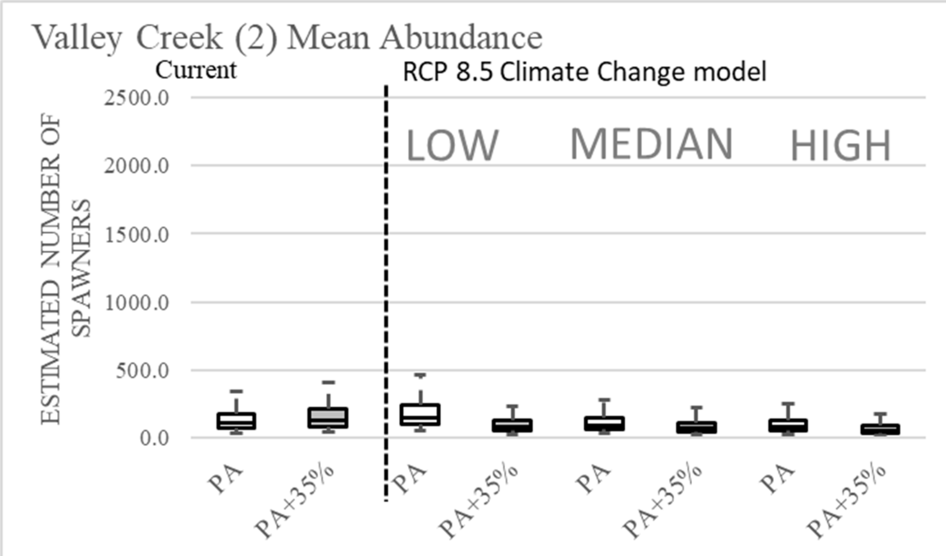

North Fork Salmon QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

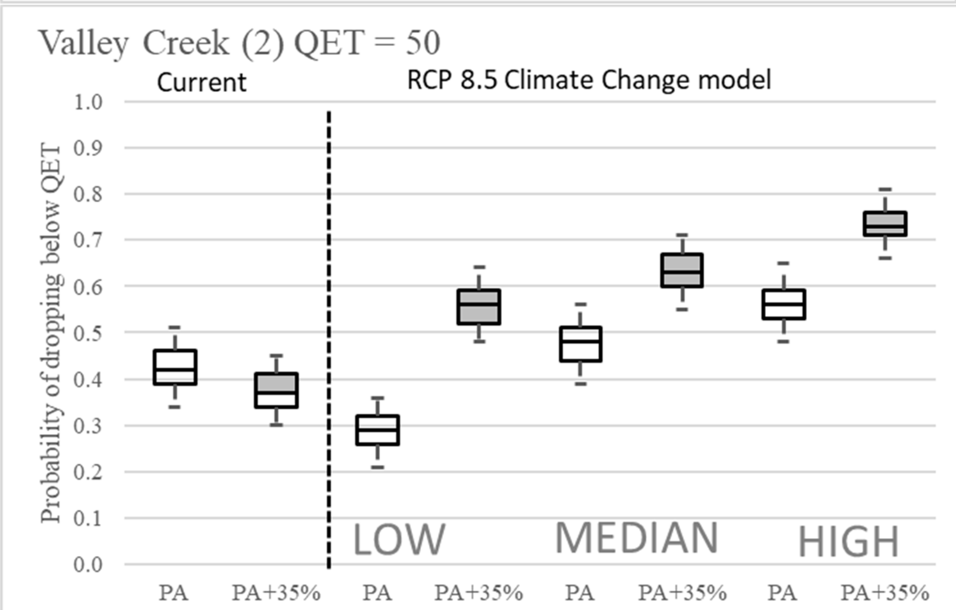

Panther Creek Mean Abundance
Current
RCP 8.5 Climate Change model
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

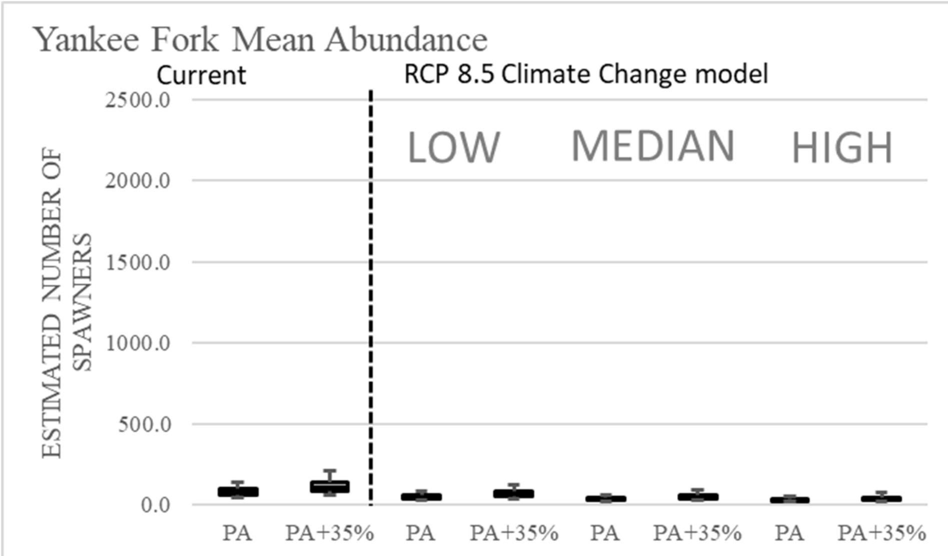

Panther Creek QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

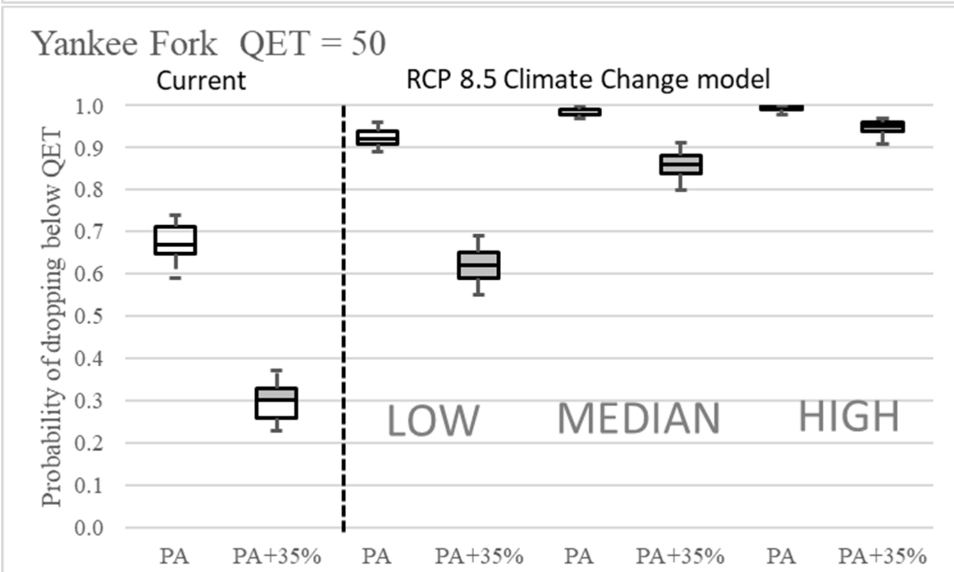

Valley Creek Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

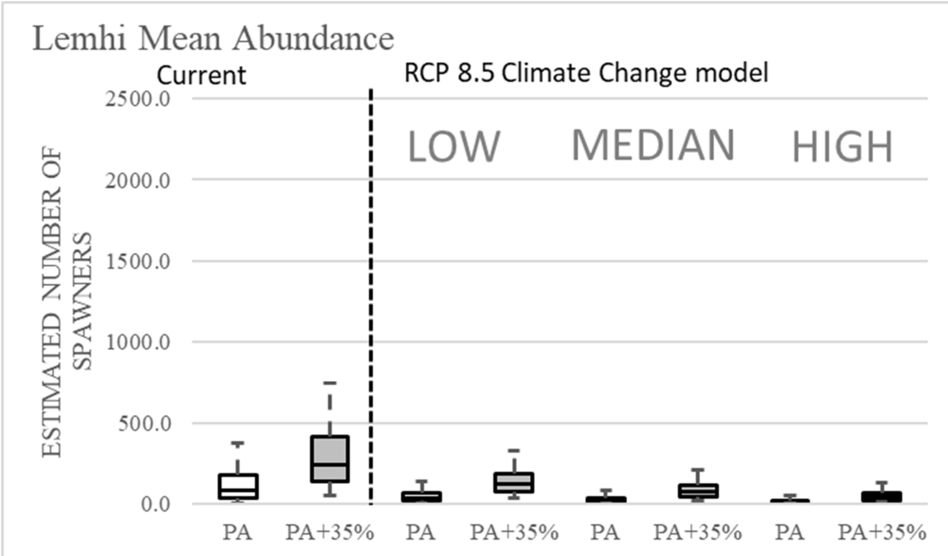

Valley Creek QET = 50
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%

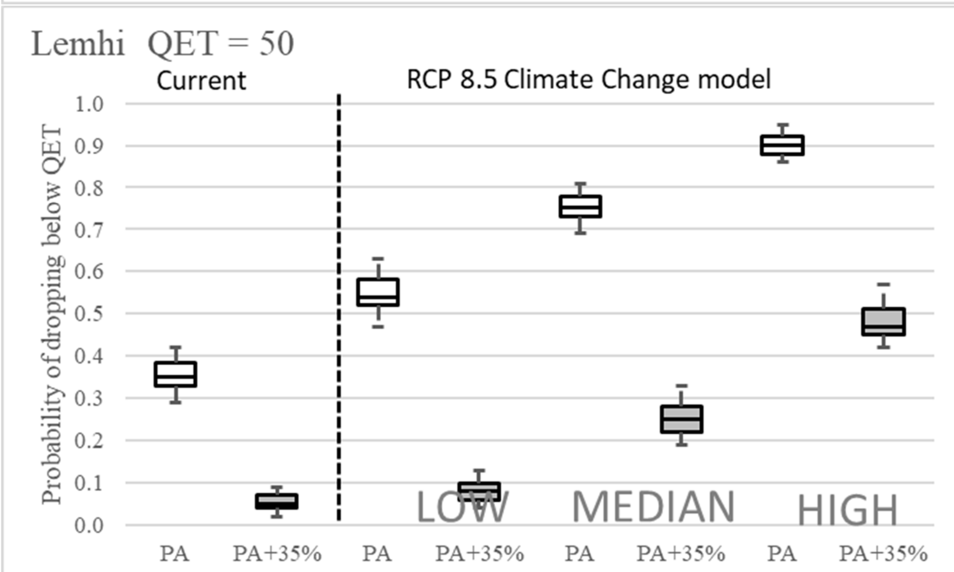

Valley Creek (2) Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Valley Creek (2) QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Yankee Fork Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Yankee Fork QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOW
MEDIAN
HIGH
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Lemhi Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
PA
PA+35%
PA
PA+35%
PA
PA+35%


Lemhi QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
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LOW
MEDIAN
HIGH
PA
PA+35%
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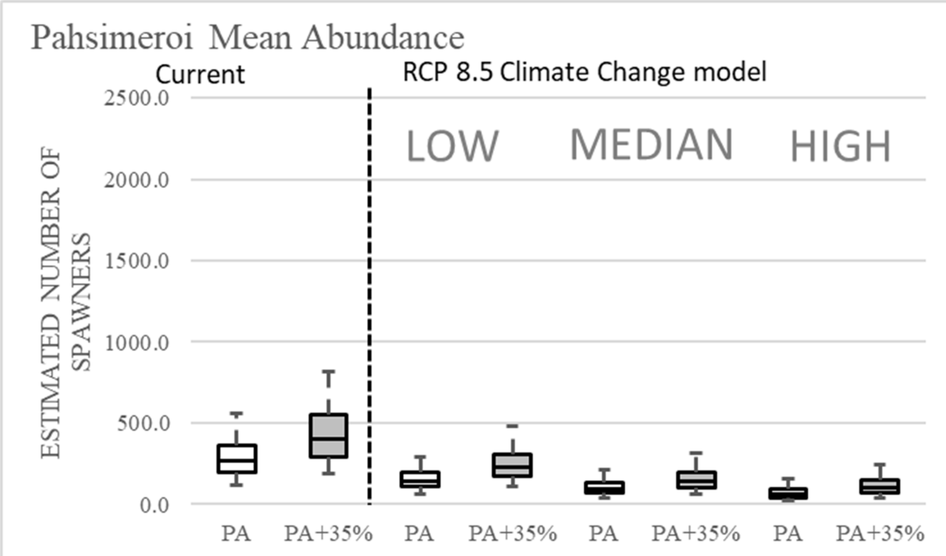
PA+35%


Pahsimeroi Mean Abundance
Current
RCP 8.5 Climate Change model
LOW
MEDIAN
HIGH
ESTIMATED NUMBER OF SPAWNERS
2500.0
2000.0
1500.0
1000.0
500.0
0.0
PA
PA+35%
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PA+35%
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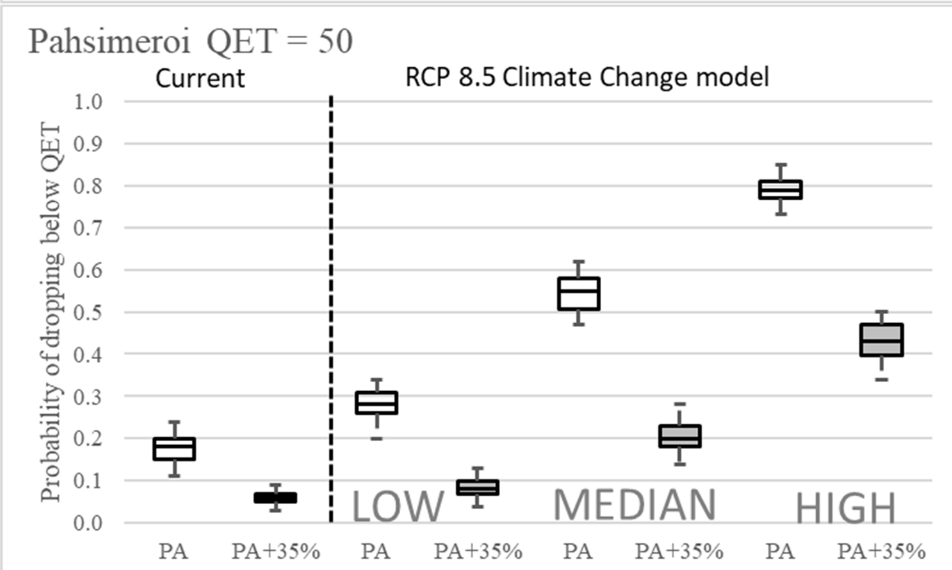
PA+35%


Pahsimeroi QET = 50
Current
RCP 8.5 Climate Change model
Probability of dropping below QET
1.0
0.9
0.8
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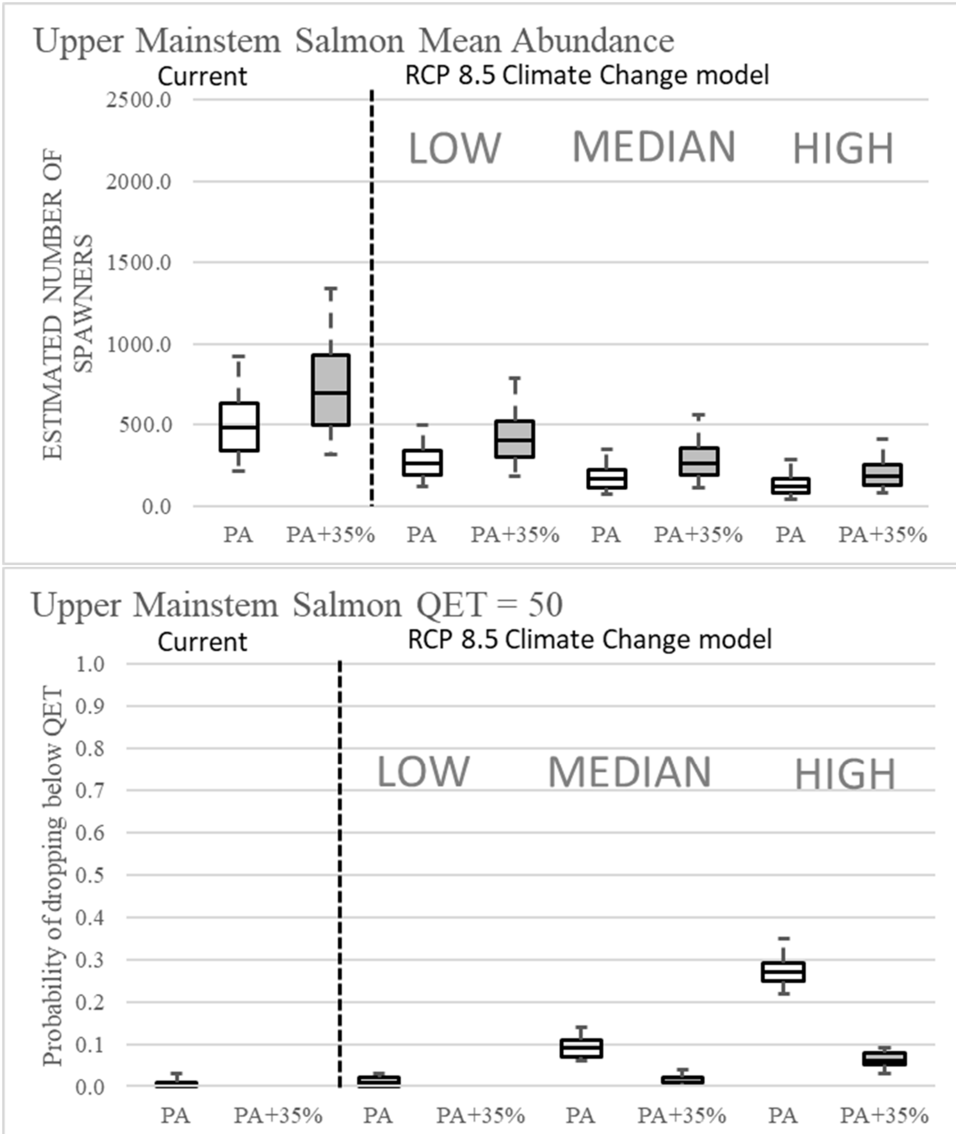

Figure 2.2-21b. Climate change analysis (RCP 8.5) of life-cycle model projections of median geomean abundance (year 15 to 24) and Quasi-Extinction Risk thresholds of 50 for Upper Salmon MPG populations of naturally produced fish in 24 years under the proposed action and assuming 35 percent increase in productivity (CSS hypothesis). Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

Discussion

Based on life-cycle modelling of future RCP 8.5 climate emission scenario for SR spring/summer Chinook salmon populations, the median abundance of stream-type spring and summer-run Chinook salmon populations could decline substantially in the next two to three decades. Declines of this magnitude, if they were to occur, would threaten to extirpate a large number of small populations, and would substantially reduce the abundance and productivity of larger populations.

Changes in the ocean phase of the life cycle, especially the sea surface temperature parameter (SST), had the greatest negative effect on survival. Figure 2.2-22 illustrates the stage-specific responses of a subset of populations when only one stage of the life cycle was affected by climate change at a time. The decline in the number of spawners is much greater during the marine phase of the life cycle than other life stages.

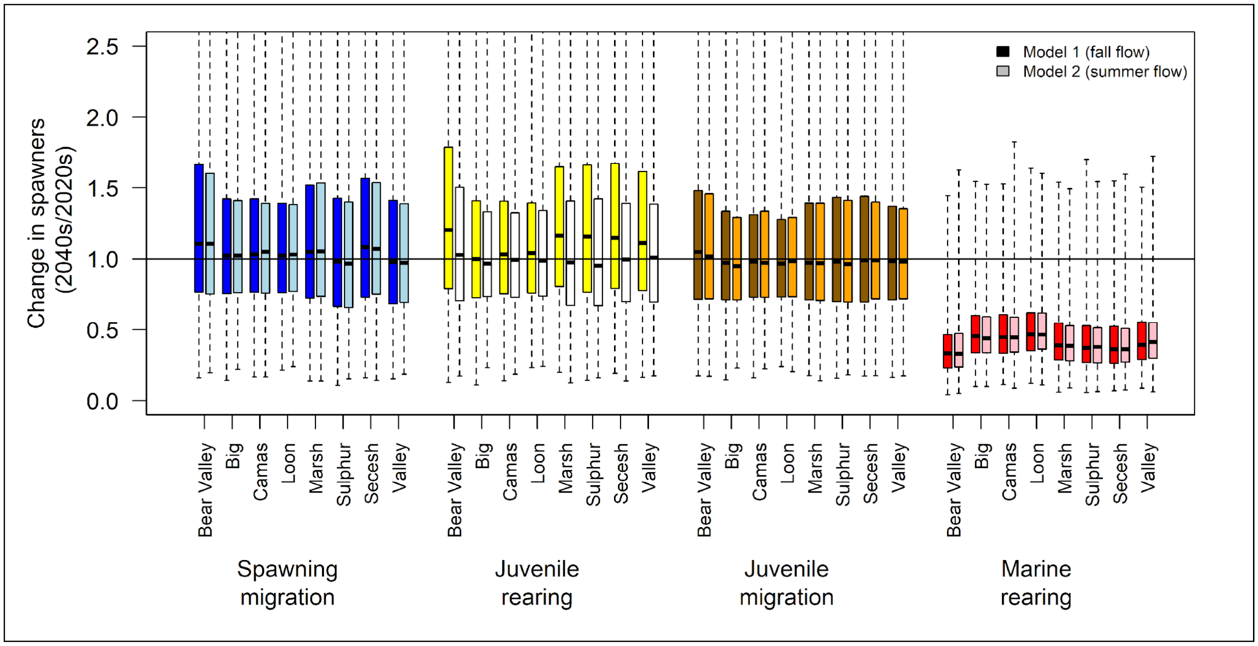

Figure 2.2-22. Effects of climate change applied one life cycle stage at a time to Middle Salmon River MPG populations expressed as change in the number of spawners between 2020 and 2040.

These results indicate that rising sea surface temperatures puts all of these salmon populations at high risk of extinction. Small populations have minimal buffer against declining marine survival rates, and are at immediate risk as can be seen from the QET 50 analyses for each MPG. The threat to larger populations (substantially reduced abundance and productivity) causes even greater concern because they are the remaining salmon strongholds, which provide genetic and demographic resilience for the ESU as a whole (McElhany et al. 2000).

Although we have focused on the details for certain populations, strong synchrony across all populations within the ESU (Jorgensen et al. 2016) suggests these responses could be characteristic of a more widespread phenomenon. Salmon populations show coherence at many spatial scales, and synchrony has increased over time in both Pacific and Atlantic populations (Chaput 2012, Black et al. 2018, Dorner et al. 2018), due in part to hatchery fish production (Cline et al. 2019). Even Alaska salmon, that have historically contrasted with southern populations by benefitting from warm phases of the PDO, no longer have a positive correlation with winter SST (Litzow et al. 2018) and are more synchronized with southern populations (Ohlberger et al. 2016). Thus, although population groups show individualistic responses, climate change overlaid on other anthropogenic forces could drive salmon declines at a large scale (Zimmerman 2015, Ohlberger et al. 2016).

Analysis of the freshwater climate impacts in this study were conservative in some respects. The high elevation, mostly-wilderness habitat of SR Chinook ESU partially explains the relatively small effects of climate change on their freshwater life stages. Other populations face more immediate impacts on freshwater productivity (Honea et al. 2016, Justice et al. 2017). Fall flows had a strong effect on juvenile survival between years in our top-ranked model, which is also the season that is least sensitive to climate change (Chegwidden et al. 2019). Summer flows could also be limiting, which would cause a more negative response. But increases in summer temperature caused a weak response in early life stages of these populations. Finally, we have assumed linear responses to environmental variables, but physiological and ecological thresholds create non-linear responses, by which high temperatures or low flows could have different (perhaps more or less severe) effects than was modeled.

Survival through the migration corridor declined for all juvenile migrants and adult summer-run migrants due to rising temperatures. Still, the declines we found were relatively small because of their early run timing compared with other salmon that migrate during peak temperatures. In particular, endangered Snake River sockeye adults experience much higher mortality from heat stress (Crozier et al. 2018, Isaak et al. 2018). In our analysis, we found relative resilience in freshwater stages and the dominant driver reducing abundance and productivity was the 96 percent decline in survival due to rising SST in the marine life stage. These modelled losses in the marine life stage, above any other single factor, pose the biggest threat to SR spring/summer Chinook salmon populations.

Caveats

There are two main caveats to these projections. First, the northeast Pacific might not warm at the rate modeled, despite rising levels of CO2 in the atmosphere. Over the past century, internal variability in the climate system represented by variation in sea level pressure and natural variability in ocean circulation has been a stronger determinant of coastal SST than global mean temperature (Johnstone and Mantua 2014). How long this situation will continue is impossible to predict. Warming might occur slower than modeled, which would delay the onset of population declines. Nonetheless, with the entire ocean warming even at depth as radiative forcing increases (IPCC 2019), at some point this signal will inevitably reach coastal waters.

The second possibility is that the northeast Pacific does warm, but some sort of ecological surprise (Lindenmayer et al. 2010) will reverse the historical relationship between SST and salmon survival. Ocean temperature does not affect salmon primarily through a physiological response, but rather through a combination of bottom up and top down ecological processes that jointly regulate salmon growth and survival (Ottersen et al. 2010, Ruzicka et al. 2016, Chasco et al. 2017), which explains the non-stationarity of statistical correlations. Warm conditions have been associated with poorer-quality prey and more warm-water predators, generating the correlation we have observed. However, it is possible that novel communities will arise with different responses to temperature, or that salmon will adapt to an altered food web in a positive manner. We do see consumption rates increase and unexpected species appear in the California Current Ecosystem (CCE) when new conditions arise, such as during the marine heatwave of 2013 to 2015. For example, anchovy (*Engraulis mordax*), sardine (*Sardinops sagax*) and hake (*Merluccius productus*) showed unusually early and northern spawning behavior, which increased concentrations of larvae in the northern CCE in the winter 2015 and 2016, which could benefit salmon (Auth et al. 2018).

Other ecological surprises should also be considered, such as increases in competitors such as jellyfish (Ruzicka et al. 2016) and Humboldt or market squid (Zeidberg and Robison 2007), which could reduce salmon survival in an altered ocean. Predators, such as seabirds that currently concentrate on alternative prey, change behavior when their preferred prey dwindle or alter their distribution, which can change (either positively or negatively) levels of predation on salmon (Wells et al. 2017).

Finally, our model does not account for any negative effects of ocean acidification. Declines of sensitive species such as crabs and calcariferous zooplankton could have a negative effect on salmon, especially salmon populations that prey extensively on these species (Marshall et al. 2017). We have assumed that salmon are relatively insensitive to pH, but if there are effects, they are likely to be negative (Ou et al. 2015, Williams et al. 2019).

Carryover effects from freshwater that could affect marine survival in these populations have primarily focused on the mainstem dams. Survival through Columbia and Snake River dams generally meets recovery targets (>96 percent) (Skalski et al. 2016), and cumulative mortality over 500 km of inriver migrating fish (~50 percent) is similar to that estimated for unregulated rivers of similar length (i.e., Fraser River (Welch et al. 2008)). However, slow travel time through reservoirs combined with high reservoir temperatures lower marine survival (Gosselin and Anderson 2017). Mitigation efforts to increase smolt body size and advance migration timing could increase marine survival (Scheuerell et al. 2009). But whether these efforts could overcome declines in marine survival due to rising SST is uncertain.

There is strong density dependence at the parr to smolt stage, although it is not clear whether summer or winter habitat is constrained. They have minimum, obvious anthropogenic impacts compared to many basins throughout the Snake River, but the mainstem Salmon River has experienced structural simplification and loss of wood, which could limit both rearing and overwintering capacity. Our results suggest that smolt carrying capacities are currently limited by flow rather than temperature. Higher flows may create more habitat, improve connectivity, or decrease contact with predators. The predator community has also been affected by human impacts, from introduced sport fish (e.g., smallmouth bass, walleye, etc.) to the creation of reservoir habitat more favorable for invasive fish (e.g., American shad, Alosa sapidissima).

Throughout the west, improving and expanding rearing habitat to increase smolt abundance and body condition would improve salmon viability (Herbold et al. 2018). Intrinsic habitat potential is negatively correlated with current levels of disturbance, so restoring prime habitat could yield substantial benefits. Specifically, habitat at lower elevation that was historically highly productive has been preferentially lost. Improving individual fish growth by reducing contaminant loads (Chittaro et al. 2018), increasing floodplain habitat (Herbold et al. 2018) and habitat complexity in general could boost population productivity (Beechie et al. 2013) and provide some climate resilience.

Summary

Climate change, especially future conditions that could substantially reduce survival during the marine life history stage, poses a substantial threat to SR spring/summer Chinook salmon, and likely to other salmon populations, especially those which rely upon a stream-type life history (reductions in productivity, abundance, and potentially, to spatial structure and diversity depending upon the severity). These conditions are not caused by, nor will they be exacerbated by, the continued operation and maintenance of the CRS as proposed in the biological assessment (BPA et al. 2020). Potential improvements from the flexible spring spill operation would be expected to improve or maintain existing survival levels (especially if the CSS hypothesis regarding latent mortality proves correct). And the implementation of the proposed non-operational conservation measures (tributary habitat and estuary habitat restoration, and predator management) should, as noted earlier in this section, contribute to resilience in the freshwater life history stages.

2.2.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small improvement to safe passage for inriver juvenile migrants at the eight mainstem dams. Adults migrating during periods of gas cap spill are likely to experience a small reduction in safe passage due to an increased rate of involuntary fallback over the spillway. Implementation will also affect the volume and timing of flow in the Columbia River, which alters habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.2-28.

Table 2.2-28. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the SR spring/summer Chinook salmon ESU.

Physical and Biological Features (PBF)	Effects of the Proposed Action
Spawning and juvenile rearing sites	The Action Agencies will implement tributary habitat improvements to achieve the MPG-level metrics outlined in Table 2.2-17. These actions are likely to improve spawning gravel, water quality (e.g., temperature), water quantity, cover/shelter, food, riparian vegetation, and space at the local scale in watersheds with spawning and rearing sites. After the first 5-year period, the proposed metrics may be adaptively managed to optimize fish benefits and the functioning of spawning and rearing sites.
Freshwater migration corridors	*Effects on migration corridor PBFs apply to all populations and MPGs of SR spring/summer Chinook salmon unless specified.* Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors).[1] The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for juvenile fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. The proposed changes to reservoir operations at Grand Coulee, Libby, Hungry

Physical and Biological Features (PBF)	Effects of the Proposed Action
	Horse, and Dworshak Dams will result in a small decrease in flows, but this will not affect the functioning of water quantity in the juvenile and adult migration corridors Continued alteration of the seasonal mainstem temperature regime in the Snake and Columbia Rivers due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and early summer, when juvenile and adult SR spring/summer Chinook salmon are migrating, and warmer temperatures in the summer and fall. In general, cooler spring temperatures will not adversely affect the functioning of water quality in the mainstem migration corridor for this species. However, water quality will continue to be negatively affected for summer-run adults, which enter the lower Columbia River during June and July. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume, which may reduce "cover/shelter" in the migration corridor. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill at the CRS run-of-river projects in the lower Snake and Columbia Rivers. The effect on water quality in terms of increased incidence of GBT is likely to be very small. The Corps will continue to protect water quality by using best management practices to minimize accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. The flexible spring operation to 125 percent TDG will reduce safe passage in the adult migration corridor by a small amount by increasing the risk of fallback over project spillways and by degrading tailrace hydraulic conditions at Little Goose, and potentially at other projects, which may contribute to passage delays for migrating adults. The flexible spring operation to 125 percent TDG will increase safe passage in the juvenile migration corridor by a small amount by increasing the likelihood of spillway passage. However, increased spill levels are likely to degrade tailrace conditions at Lower Granite, Little Goose, and John Day Dams (safe passage in the migration corridor), increasing the risk of bird and fish predation under low flow conditions. Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (increase in safe passage). However, by increasing powerhouse flows, it will decrease safe passage for juveniles and adults by a small amount because some will pass downstream or fall back through a turbine unit. Increased operating range for John Day Reservoir will reduce the risk of avian predation while increasing juvenile travel times by a small amount (small reduction in predation and slight decrease in safe passage).

Physical and Biological Features (PBF)	Effects of the Proposed Action
	The potential cessation of power generation at Snake River projects between 2300 and 0500 hours, October 15 to February 28, is not likely to affect safe passage for SR spring/summer Chinook salmon because very few juveniles and no adults are present during this period. Continued small increases in obstructions for adult spring/summer Chinook salmon during routine outages of fishways or turbine units. Very small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities (e.g., to upgrade turbines at Ice Harbor, McNary, and John Day Dams and for a major repair such as the jetty and retaining wall at Little Goose Dam). Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Long-term effect of turbine upgrades will be reduced obstructions (improved turbine survival). Repairing the jetty at Little Goose Dam will also reduce obstructions for adults at that project. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Continued implementation of the Action Agencies' bird, fish, and pinniped predator management programs will continue recent levels of predation risk in the juvenile and adult migration corridors.
Estuarine areas	*Effects on the estuarine areas PBF apply to all populations and MPGs of SR spring/summer Chinook salmon.* Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels. This will increase access to prey, even for yearling Chinook salmon that migrate in the mainstem channel without entering floodplain sites. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, warming has begun as early as June or July and has been more severe.

2.2.4 Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area’s future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.2.1), Environmental Baseline (Section 2.2.2), and Effects of the Action (Section 2.2.3) sections and in the Effects of the Action (Life-Cycle Modeling Section (2.2.3.1.12).

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat, and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities and increased flow through storage projects. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including SR spring/summer Chinook salmon.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include activities associated with human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will have beneficial effects on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.2.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.2.3) to the environmental baseline (Section 2.2.2) and the cumulative effects (Section 2.2.4), taking into account the status of the species and critical habitat (Section 2.2.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.2.5.1 Species

The SR spring/summer Chinook salmon ESU comprises 28 extant populations in five MPGs. Three populations are functionally extirpated, and one population is extirpated. The most recent status review (NMFS 2016b) indicated that most populations (19 of 22 populations for which estimates were available) increased in abundance, compared to the previous review, but that all but one population remained at high overall risk. The Chamberlain Creek population (Middle Fork Salmon River MPG) was rated as maintained. More recent adult returns (2014 to 2019) have been substantially below average for most, but not all, populations/MPGs. This downturn is associated with a marine heatwave and its lingering effects, which likely contributed to substantially lower ocean survival rates of juvenile spring and summer Chinook salmon. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants. However, jack returns suggest that adult numbers could remain at low levels in 2021. The Recovery Plan (NMFS 2017a) identified several factors that are limiting the viability of SR spring/summer Chinook salmon populations: tributary habitat degradation, estuarine habitat degradation, hydropower, harvest, hatchery programs, predation, and additional factors (exposure to toxic contaminants and the effects of climate change).

With the exception of the Tucannon River population, which must pass six mainstem dams, SR spring/summer Chinook salmon populations must pass eight mainstem dams on the lower Snake and lower Columbia rivers to reach the ocean and return to their spawning grounds. Conditions for SR spring/summer Chinook salmon populations have generally improved in the mainstem Columbia River because of the installation and operation of surface passage routes, 24-hour spill, improved spill patterns, and improvements to the juvenile bypass systems at the mainstem dams. Lower Granite Dam to Bonneville Dam survival rates for hatchery and natural-origin yearling Chinook salmon vary substantially (43 to 63 percent), but have averaged about 53 percent the past 10 years (2010 and 2019) (Zabel 2019, Widener et al. 2020).

The juvenile survival rates from Lower Granite Dam to Bonneville Dam include all sources of mortality, even those that are not caused by the past or proposed operation and maintenance of the CRS. For instance, regardless of the operational or configurational choices made for the hydrosystem, some predation and other natural mortality of juvenile SR spring/summer Chinook salmon would occur during their migration. In addition, juvenile survival is influenced by past and present alterations of shoreline habitat, among other stressors, unrelated to the effects of operating the hydrosystem; many of those effects will continue into the future. We are unable to differentiate the proportion of the losses that result from the operation and maintenance of the mainstem dams rather than to the existence of the dams, but we know that the mortality attributable to operations and maintenance is less than the losses captured in the overall survival estimates. As discussed further below, some also hypothesize that passage through juvenile bypass systems and turbines causes latent mortality, which would not be captured in the direct survival estimates.

Juvenile Chinook salmon are transported from Lower Granite, Little Goose, and Lower Monumental Dams. Transport rates have decreased substantially since about 2007, primarily as a result of later transport start dates (May 1 from 2008 to 2017), earlier migration timing, and higher spill levels. Transport operations began earlier in 2018 (April 23), 2019 (April 24), and 2020 (April 24) in order to increase the proportion of juveniles transported (decreasing the proportion of juveniles that would otherwise be bypassed to continue migrating in the river). The benefit of transport (adult returns of transported fish relative to those bypassed back to the river) varies throughout the season (benefits generally increase from early April until late May), but annual averages have favored transported fish since 2008, except in 2011, when the relative returns of bypassed fish were somewhat higher than that of transported fish. We expect that the proposed earlier transport start dates, and juvenile monitoring associated with the adaptive management program, should ensure that transport will continue to provide benefits to SR spring/summer Chinook salmon and be responsive to potential future changes in juvenile migration timing.

Adult survival rates (adjusted to account for reported harvest and typical straying rates), include "natural" mortality as well as any mortality associated with injuries incurred from predators. Adult survival rates for SR spring/summer Chinook salmon are relatively high, averaging about 89 percent between Bonneville and McNary Dams and 83 percent between Bonneville and Lower Granite Dams. Increased spring spill levels are expected to slightly increase adult fallback rates. Not all individuals that fall back will successfully reascend the fishways, and those that do will experience some delay. However, the potential for loss will be reduced by the fact that more of these adults will have fallen back through spillbays, which have higher survival rates than juvenile bypass systems or turbine units.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Overall, scheduled maintenance activities are expected to continue to negatively affect very few SR spring/summer Chinook salmon that are migrating during scheduled maintenance periods. Non-routine and unscheduled maintenance can affect juvenile and adult passage and survival, especially if these events occur during the freshet, but because they are sporadic in nature and coordinated through the inseason adaptive management process, the alternative measures as coordinated in FPOM (e.g., alternative spill, or turbine unit priorities) will likely minimize these impacts.

The proposed spring spill levels would implement a program of voluntary fish passage spill with the highest spill volumes ever implemented. This will increase juvenile exposure to higher TDG levels; however, it is unlikely that spilling up to 125 percent TDG for 16 hours per day at most mainstem dams[74] will result in any substantial, negative impacts to juvenile survival (or adult passage) because there are sufficient data and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). The proposed 125 percent flexible spill operation could improve direct juvenile survival rates through the four lower Snake and four lower Columbia river mainstem projects (with the possible exception of Bonneville Dam, where survival rates could decrease slightly, and at The Dalles Dam, which will maintain spill levels of 40 percent). NMFS' COMPASS model predicts that inriver survival rates will increase slightly as a result of increased spring spill levels associated with the flexible spill operation compared to the No Action Alternative (USACE et al. 2020). The CSS model predicts more substantial increases in juvenile survival, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillbays) will increase adult returns of the Snake River populations by about 35 percent. If these predictions are realized, they would represent a substantial near-term improvement in productivity and abundance for SR spring/summer Chinook salmon (as demonstrated by NMFS' life-cycle modeling of the proposed action plus a 35 percent productivity improvement) and, over time, would reduce the severity of expected declines in abundance and productivity caused by a warming climate and deteriorating ocean conditions.

Tributary habitat conditions for SR spring/summer Chinook salmon vary significantly throughout the Snake River basin, depending on historical and current land use activities and natural conditions. Generally, the ability of tributary habitats in the Snake River basin to support the viability of this ESU is limited by one or more of the following factors: 1) impaired fish passage, 2) reduced stream complexity and channel structure, 3) excess fine sediment, 4) elevated summer water temperature, 5) diminished stream flow during critical periods, 6) reduced floodplain connectivity and function, and 7) degraded riparian condition.

[74] Except at John Day Dam, The Dalles, and Bonneville Dam, where proposed spill operations are limited to 120 percent TDG, 40 percent spill, and 150 kcfs, respectively.

Many habitat improvement actions have been implemented throughout the Snake River basin. These actions have been targeted toward addressing limiting factors, and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. NMFS has determined that these actions have improved, and will continue to improve, habitat in the targeted populations as these projects mature, and that fish population abundance, productivity, spatial structure, and diversity will respond positively. The benefits of some of these actions will continue to accrue over several decades. At the same time, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

While tributary habitat conditions in the SR spring/summer Chinook salmon ESU are likely improving in some areas, in general, they are still degraded and continue to negatively affect SR spring/summer Chinook salmon abundance, productivity, spatial structure, and diversity. The potential exists to further improve tributary habitat capacity and productivity in this ESU, although the potential appears to be limited in some populations. Additional tributary habitat improvements are needed to achieve recovery goals.

Implementation of the tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will provide additional near-term and long-term benefits to the targeted populations by improving tributary habitat in the manner and timeframes outlined in Table 2.2-18, above. In addition, certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change (Beechie et al. 2013, McCullough et al. 2016, Justice et al. 2017). Crozier et al. (2019) looked at methods of increasing climate resilience in their 2019 climate vulnerability assessment for Pacific salmon and steelhead. They found that reducing anthropogenic stressors could greatly improve responses to climate change by improving the overall status of an ESU in terms of abundance, productivity, spatial structure, and diversity. A robust ESU has greater resilience by virtue of strong population dynamics that make stochastic extinction less likely. Actions implemented to ameliorate limiting factors for any population would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced.

These benefits will accrue in three of the five MPGs in this ESU (the Upper Salmon, Grande Ronde/Imnaha, and Lower Snake River MPGs). For two of the five MPGs (the South Fork Salmon and the Middle Fork Salmon), the proposed tributary habitat actions will have no effect on the populations in the MPGs, because the Action Agencies have not proposed to implement any actions in those MPGs. These improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action. Further, to yield substantial improvements, it is necessary to implement a large scale and scope of habitat improvement actions (e.g., implementation over a 25-year time period or longer), and to implement actions throughout a large portion of each watershed. Thus, it is important to consider the results of the habitat actions to be implemented under this proposed action in the context of the effects of long-term implementation of habitat actions.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving SR spring/summer Chinook salmon abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this ESU. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan, the Double-crested Cormorant Management Plan, and the IAPMP, as well as hazing at the mainstem dams. For SR spring/summer Chinook salmon, we expect that management of tern colonies throughout the basin is reducing mortality by a small amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that prey on yearling Chinook salmon are also present in the hydrosystem reach. Increasing the John Day reservoir elevation in the spring should control impacts from the Blalock Islands tern colony. The NPMP and dam angling program are expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested Cormorant Management Plan, these programs will maintain current (reduced) levels of predation, creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on SR spring/summer Chinook salmon in the lower Columbia River and estuary has increased substantially with recent increases in the abundance of sea lions, especially in the spring. However, estimated losses in the Bonneville tailrace have declined recently, ranging from about 3 to 5 percent since 2016. Sea lion predation downstream of Bonneville Dam, including the estuary, continues to substantially and negatively affect the productivity and abundance of SR spring/summer Chinook salmon.

The past effects of artificial production programs have largely been to increase abundance and help preserve genetic resources—especially true for safety net or conservation hatchery programs during times of low abundance. However, these programs have also posed risks to natural productivity and genetic diversity. There are currently 18 spring/summer Chinook hatchery programs in the Snake River basin. The effects of these programs are covered through separate biological opinions, and have generally reduced the negative consequences of these programs to natural populations. Clearwater River programs have implemented new strategies to limit straying into other basins where natural-origin ESA-listed fish are present. In the South Fork Salmon River MPG, hatchery programs have integrated natural-origin fish into their broodstock to lessen the potential negative effects of hatchery produced fish on naturally produced populations. Captive-rearing experiments have been terminated in the Upper Salmon River MPG, and the Sawtooth hatchery has integrated natural-origin fish into its broodstock. Hatchery programs in the Grande Ronde and Imnaha River basins are managed under a sliding-scale program that allows some hatchery-origin fish to spawn in the wild, but reduces the proportion of hatchery fish as natural-origin abundance increases, in an attempt to better balance the risk of extinction (low natural-origin abundance) with the risk of hatchery influence. Taken together, these actions generally allow for the production of fish for harvest and conservation while reducing the genetic risk of the hatchery-produced fish to natural populations within MPGs, and to the ESU as a whole. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of SR spring/summer Chinook salmon.

The largest harvest-related effects on SR spring/summer Chinook salmon result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery (including the estimated effects of recreational fisheries in the lower Snake River) and estimated that harvest rates should continue to average around 12 percent (including an estimated 10 percent mortality of wild-released fish). In addition, several fisheries also operate in the Snake River basin upstream of Lower Granite Dam in the mainstem Snake River, Lower Salmon River, South Fork Salmon River, Upper Salmon River, Clearwater River, and Grande Ronde and Imnaha Rivers.

As described in Section 2.2.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect SR spring/summer Chinook salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of SR spring/summer Chinook salmon as very high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change. However, the severity of those changes would be reduced as a result of the proposed action.

Spring-migrating adults could potentially respond temporally to changing environmental conditions by migrating earlier in the spring. Summer-migrating adults would be exposed to increasing summer temperatures in the migration corridor. Both spring and summer migrants would be exposed to higher summer temperatures as they hold in tributary streams before spawning. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or winter flood events). Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in streams. Juveniles using a stream-type, yearling life-history strategy would be exposed to higher summer temperatures in tributaries, though juvenile migrants could potentially respond temporally by migrating earlier in the spring. Though the quality of information is mixed, sensitivity in the marine stage is certainly high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur.

NMFS’ life-cycle modeling, which considered three potential levels of changing climate severity over the next 24 years, clearly indicates that climate change effects, especially those that may manifest in the ocean, pose a substantial threat as they can have severe, negative consequences to the overall productivity (and abundance) of all SR spring/summer Chinook salmon populations (see Life Cycle Modeling). Based on the modeling, we expect abundances over the next 24 years to decrease and extinction risk to increase, even when taking into account the benefits of the proposed non-operational conservation measures and the most optimistic hypotheses related to reduced latent mortality. These climate change consequences are not caused by the proposed action, and elements of the proposed action (flexible spring spill operations, tributary and estuary habitat restoration and research, monitoring, and evaluation programs) should help to improve the resiliency of SR spring/summer Chinook salmon populations to expected climate change effects. In simple terms, even if the adult abundance declines as predicted under climate change, which will make recovery of this ESU more challenging, it will have declined less as a result of the proposed action because in many ways the proposed action is expected to improve the functioning of VSP parameters and thus positively contribute to the survival and recovery of the species.

The proposed action—the future operation and maintenance of the CRS (including upper Columbia River operations and Dworshak Dam winter operations to reduce TDG in the lower Clearwater River)—will have little overall effect on the seasonal hydrograph or seasonal temperatures compared to recent conditions. The seasonal hydrograph will continue to be altered, generally increasing flows in the fall and winter and reducing flows in the spring. Seasonal water temperatures will also continue to be altered, with delayed warming in the spring, delayed cooling in the fall, and reduced daily temperature variability. These effects to river conditions likely adversely affect the survival of SR spring/summer Chinook salmon, but to an extent not readily quantified based on the best available information.

Other operations (e.g., operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, increasing the John Day reservoir operating range during the spring to reduce avian predation, etc.) are, collectively, expected to have small negative effects, especially on juvenile migrants, but these effects should not measurably alter survival estimates between Lower Granite and Bonneville Dam.

The proposed action includes many measures to reduce the adverse effects of the passage impediments caused by the existence of the CRS, including juvenile fish passage spill, operation of juvenile bypass systems, attraction flows for adults, and the operation of adult fish ladders. In addition to these measures, the proposed flexible spring spill operation is expected to improve juvenile survival through the mainstem migration corridor for all populations, and if the flexible spring spill operation increases adult returns by up to 35 percent as hypothesized by the CSS, SR spring/summer Chinook salmon would experience a substantial near-term improvement in productivity and adult abundance over current conditions. Adaptively managing transport operations (using juvenile migration monitoring and seasonal patterns in adult returns to guide start date decisions) will likely continue to improve adult returns (relative to bypassed fish).

Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this ESU (e.g., dam passage survival, population productivity, degraded tributary and estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.).

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity and is likely to affect marine survival (to an unknown extent) through latent mortality. Since 2008, actions have been taken to reduce adverse impacts associated with the operation of the CRS and to address factors limiting survival and recovery (e.g., tributary and estuary habitat, predation, etc.). Evidence shows that these actions have resulted in improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The recent downturn in adult abundance (2014 to 2019) is primarily the result of recent poor ocean conditions and not of altered tributary and mainstem habitat conditions. The proposed action carries forward structural and operational improvements implemented since 2008 and improves upon them. Additional juvenile survival improvements are expected from the flexible spring spill operation and potential improvements resulting from reduced latent mortality are possible, and ecosystem functions should continue to increase in tributary and estuary habitats where improvement actions occur.

Climate change is a substantial threat to SR spring/summer Chinook salmon, especially during the marine rearing phase of their life cycle. The proposed action is expected to reduce both the scope and severity of those impacts and not exacerbate them. The proposed action therefore is expected to increase the resiliency of the populations to climate change and provide time for additional recovery actions to be implemented.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of SR spring/summer Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of SR spring/summer Chinook salmon.

2.2.5.2 Critical Habitat

Designated critical habitat for SR spring/summer Chinook salmon consists of all estuarine and river reaches of the mainstem Columbia, Snake, and Salmon Rivers, and all tributaries of the Snake and Salmon Rivers (except the Clearwater River) presently or historically accessible to SR spring/summer Chinook salmon (except above natural falls and Hells Canyon Dam). Across subbasins in the Interior Columbia Recovery Domain with PBFs for SR spring/summer Chinook salmon, land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity. Past and current land use and water management activities have adversely affected the quality and quantity of stream and side channel areas, riparian conditions, floodplain function, sediment conditions, and water quality and quantity. As a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

Measures taken through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies, in the decades since critical habitat was designated have improved the functioning of spawning and rearing area PBFs. These include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. However, more improvements will be needed before many areas function at a level that supports the recovery of SR spring/summer Chinook salmon. Under the proposed action, the Action Agencies will implement a suite of habitat actions to further improve the functioning of spawning gravel, water quality (e.g., temperature), water quantity, cover/shelter, food, riparian vegetation, and space at the local scale in watersheds with spawning and rearing sites. These include enhancing flow; access; stream complexity, including floodplain connectivity; and riparian function; and screening diversions, in the Grande Ronde/Imnaha, Upper Salmon, and lower Snake River subbasins. Climate change is likely to decrease streamflow (water quantity) and increase temperature (water quality) in some spawning and rearing areas, depending on their specific characteristics and locations. These risks underscore the importance of the Action Agencies' habitat restoration program, especially actions that restore riparian vegetation, streamflow and floodplain function, to improve habitat resiliency.

The environmental baseline also includes a broad range of past and present actions and activities, including effects of the hydrosystem, that have affected the conservation value of critical habitat in juvenile and adult migration corridors for SR spring/summer Chinook salmon. Some of these past effects will continue under the proposed action: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and passage delays (reduction in safe passage). These factors have increased the likelihood of excessive predation on juvenile and adult SR spring/summer Chinook salmon and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The proposed action carries forward structural and operational improvements since 2008 that address these effects on PBFs and in some cases, improve upon them. The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors.

The Action Agencies also have reduced effects of their operations on juvenile salmonid travel time and survival by increasing levels of spring spill. We expect the additional flexible spring spill to 125 percent TDG to reduce water quality in the juvenile and adult migration corridors by a small amount while having a small positive effect on safe passage at CRS projects in the lower Snake and Columbia Rivers through increased spillway passage. On the other hand, higher spill levels will reduce safe passage for adults by a small amount by increasing the risk of fallback and, in low runoff years, could degrade tailrace conditions for juvenile migrants at Lower Granite, Little Goose, Lower Monumental, and John Day Dams, increasing the risk of bird and fish predation. However, there is sufficient flexibility through the in-season management process to identify and remedy negative effects through modified spill patterns.

Operating turbines above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction for adults (increase in safe passage). However, by increasing powerhouse flows, it will decrease safe passage by a small amount because some adults will fall back or juveniles will move downstream through turbines or bypass systems.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems.

Scheduled maintenance activities are expected to continue to have short-term, very small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors.

In summary, the proposed action is not likely to further limit water quantity or water quality or to reduce safe passage in the juvenile or adult migration corridors by a meaningful amount. In addition, if the CSS hypothesis regarding latent mortality is correct, the flexible spill program could improve the functioning of the juvenile migration corridor to a much greater extent than indicated by the likely effects on safe passage described above.

Increasing the elevation of John Day Reservoir to cover nesting areas on the Blalock Islands will limit the risk of predation by Caspian terns by delaying nesting until about 95 percent of steelhead outmigrants have passed McNary Dam, which will also protect most juvenile SR spring/summer Chinook salmon. The Action Agencies also will continue to implement measures to reduce pinniped predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the hydrosystem and the estuary, and the predation management programs for Caspian terns on the interior plateau and for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will reduce or maintain the levels of predation within the juvenile and adult migration corridors that were seen in recent years, although cormorant predation rates may increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. The Action Agencies' proposed estuary habitat program will continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling Chinook salmon migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of SR spring/summer Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of SR spring/summer Chinook salmon designated critical habitat.

2.2.6 Conclusion

After reviewing and analyzing the current status of SR spring/summer Chinook salmon and its designated critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SR spring/summer Chinook salmon or destroy or adversely modify its designated critical habitat.

2.3 Snake River Basin (SRB) Steelhead

This section applies the analytical framework described in Section 2.1 to the SRB steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the SRB steelhead DPS or destroy or adversely modify its critical habitat.

2.3.1 Rangewide Status of the Species and Critical Habitat

The status of the SRB steelhead DPS is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.3.1.1 Status of the Species

2.3.1.1.1 Background

On August 18, 1997, NMFS listed the SRB steelhead DPS as a threatened species (62 FR 43937). The threatened status was reaffirmed on January 5, 2006 (71 FR 834) and most recently on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that this DPS should retain its threatened status (81 FR 33468). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52630). The summary that follows describes the status of SRB steelhead. More detailed information can be found in the recovery plan (NMFS 2017a) and most recent status review for this species (NMFS 2016b).[75]

The SRB steelhead DPS includes all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho. The DPS includes 24 extant populations (and one extirpated population), which are aggregated into five MPGs based on genetic, environmental, and life-history characteristics. Historically, SRB steelhead also spawned and reared in areas above the Hells Canyon Dam Complex on the Snake River and in the North Fork Clearwater River drainage. Steelhead are currently blocked from historical habitat in these areas. The ICTRT identified one historical MPG for the area above the Hells Canyon Dam Complex, but this MPG is extirpated and not required for ESA delisting. The DPS also includes six artificial

[75] In addition, a technical memo prepared for the status review contains more detailed information on the biological status of the species (NWFSC 2015).

propagation programs (NMFS 2017a, 71 FR 834).[76] Figure 2.3-1 shows a map of the DPS and its component MPGs; Table 2.3-1 lists the populations within each MPG and the hatchery programs that are part of the DPS.

Table 2.3-1. SRB steelhead DPS major population groups and component populations, and hatchery programs (NMFS 2017a, 71 FR 834).

Major Population Group	*Populations*
Grande Ronde	Joseph Creek Upper Grande Ronde River Lower Grande Ronde River Wallowa River
Imnaha River	Imnaha River
Clearwater	Lower Mainstem Clearwater River North Fork Clearwater River (extirpated) Lolo Creek Lochsa River Selway River South Fork Clearwater River
Salmon River	Little Salmon Rivers Chamberlain Creek Secesh River South Fork Salmon River Panther Creek Lower Middle Fork Salmon River Upper Middle Fork Salmon River North Fork Salmon River Lemhi River Pahsimeroi River East Fork Salmon River Upper Mainstem Salmon River
Lower Snake	Tucannon River Asotin Creek
Hatchery Programs	
Hatchery programs included in DPS (6)	Tucannon River Dworshak National Fish Hatchery

[76] For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in a DPS, see NMFS (2005c). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including SRB steelhead (81 FR 72759). The proposed changes for hatchery program inclusion in this DPS were to add the Salmon River B-run Program and the South Fork Clearwater B-run Program, and remove the Lolo Creek and North Fork Clearwater Programs, both now considered part of the Dworshak National Fish Hatchery Program. We expect to publish the final revisions in 2020.

Major Population Group	*Populations*
	Lolo Creek North Fork Clearwater East Fork Salmon River Little Sheep Creek/Imnaha River Hatchery

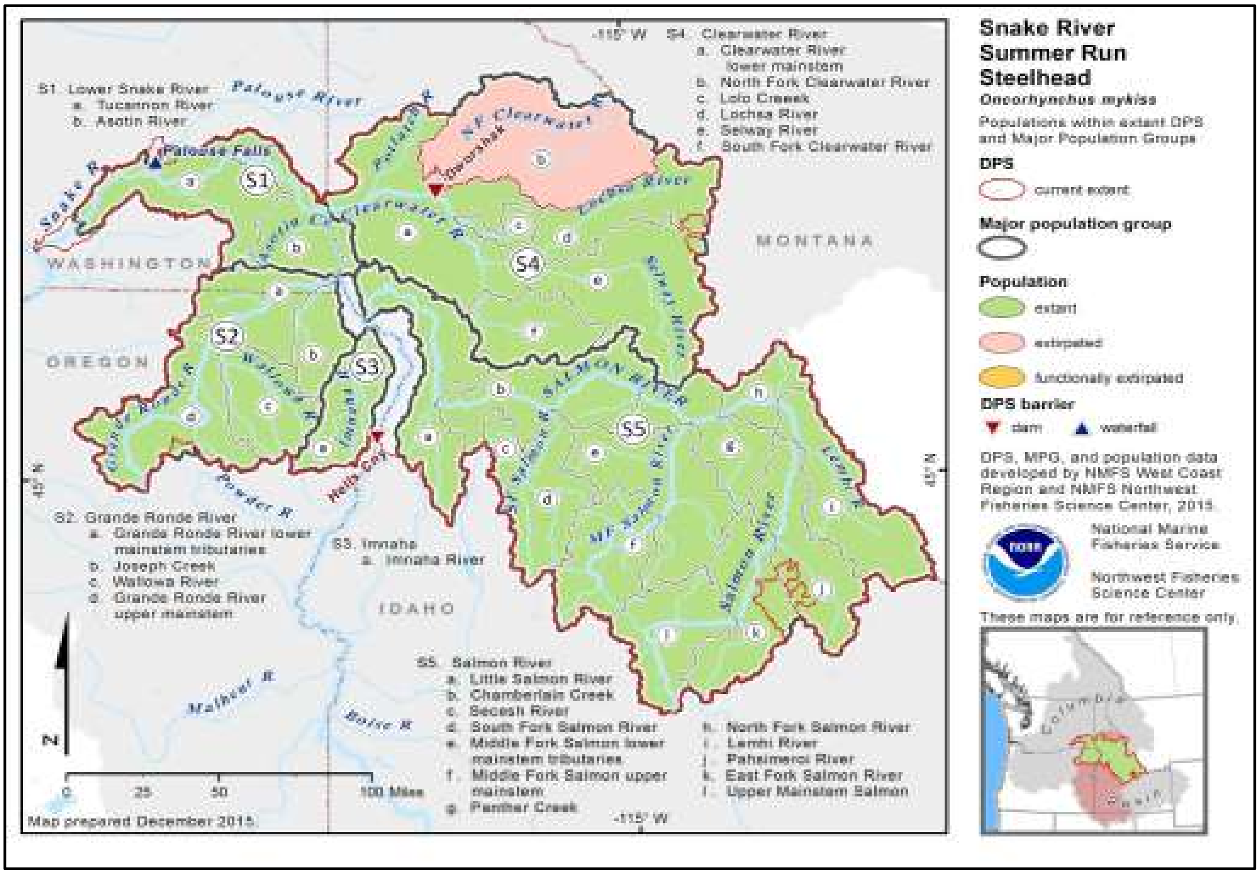

Figure 2.3-1. Map illustrating SRB steelhead DPS's populations and major population groups (NWFSC 2015).

2.3.1.1.2 Life-History and Factors for Decline

SRB steelhead are generally classified as summer-run fish. Summer-run steelhead are sexually immature when they return to freshwater, and require several months to mature and spawn. Adult SRB steelhead generally enter the Columbia River from June to August (NMFS 2017a). The peak passage of SRB steelhead has shifted by about two weeks from late July to early August, probably in response to warming temperatures and reduced flows (NMFS 2014a). SRB steelhead can delay their migration up the Columbia and Snake Rivers, and pull into cooler tributaries for temporary holding (NMFS 2017a). Most adults pass Lower Granite Dam by fall, although a small number (approximately 2.0 percent) remain below Lower Granite Dam over the winter and move upstream in the spring (April 3 through June 20).[77] Adults generally hold in larger rivers for several months before moving upstream into smaller tributaries to spawn (NMFS 2017a). During this holding period, they live primarily off stored energy, with little or no feeding (Shapovalov and Taft 1954). Most adults disperse into tributaries from March through May, but potentially into June in higher elevations. Spawning begins shortly after fish reach spawning areas, typically during a rising hydrograph and before peak flows (Thurow 1987, NMFS 2017a).

Juveniles generally emerge from redds by early June in low elevation streams and by mid-July or later at higher elevations. Juveniles in the Snake River basin typically reside in freshwater for no more than 2 years, but may stay longer, depending on temperature and growth rate (Fuller et al. 1984, Kucera and Johnson 1986, Chandler and Richardson 2006, NMFS 2017a). Smolts migrate downstream during spring runoff, which occurs from March to mid-June in the Snake River basin, depending on elevation. Juvenile outmigrating steelhead often reach Bonneville Dam by mid-May, and most travel rapidly (<5 days) through the estuary and into the ocean, although there is considerable variation in travel times and timing of estuarine and ocean entry between individual fish (NMFS 2017a). Steelhead are iteroparous, or capable of spawning more than once before death. Iteroparity as a life-history trait remains in several tributaries of the Snake River basin.

Fisheries managers classify SRB steelhead into two aggregate or morphological groups, A-Index and B-Index,[78] based on length of time spent in the ocean, size at return, and migration timing. Generally, A-Index steelhead are smaller (<78 cm [usually 58 to 66 cm] long), spend 1 year in the ocean, and begin their upriver freshwater migration earlier in the year than B-Index steelhead. B-Index steelhead are larger (many >78 cm long), spend 2 years in the ocean, and begin their upriver freshwater migration later in the year. These two groups represent an important component of phenotypic and genetic diversity of the SRB steelhead DPS through the asynchronous timing of ocean residence, segregation of spawning in larger and smaller streams, and possible differences in the habitats of the fish in the ocean (NMFS 2017a). A-Index steelhead occur throughout the steelhead-bearing streams in the Snake River basin and inland Columbia River, while B-Index steelhead only occur in the Clearwater River basin and the lower and middle Salmon River basin. Some populations support both A-Index and B-Index life-history expressions (NWFSC 2015).

Historically, the Snake River basin is thought to have produced more than half of all summer steelhead in the Columbia River basin. Several factors contributed to their declines. Harvest rates soared in the late 1800s and remained high until the 1970s. At the same time, increased European-American settlement resulted in the deterioration of habitat conditions due to logging,

[77] Approximately 2.0 percent of all adults (hatchery plus unclipped “wild” SRB steelhead) and 4.0 percent of the unclipped “wild” steelhead move upstream from April 3 through June 20, based on a query of data from 2010-11 through 2019-20. Source: Columbia River DART accessed June 2, 2020 (DART 2020d).

[78] In all previous CRS consultations, we used the terms A-run and B-run. We are using this new terminology to be consistent with terminology used by fisheries managers and to reflect a better understanding of the phenotypic and genotypic diversity within SRB steelhead.

mining, grazing, farming, irrigation, development, and other land use practices that cumulatively reduced access to and productivity of spawning and rearing habitat, increased sediment contributions to streams, reduced instream flows, and increased stream temperatures (NMFS 2017a).

Large portions of historical habitat were blocked in 1901 by construction of Swan Falls Dam on the Snake River and later by construction of the three-dam Hells Canyon Complex from 1955 to 1967. Dam construction also blocked and/or hindered fish access to historical habitat in the Clearwater River basin, as a result of construction of Lewiston Dam (built in 1927 and removed in 1973) and Dworshak Dam, which extirpated steelhead in the North Fork Clearwater River subbasin in the 1970s. The production of SRB steelhead was further affected by the development of the eight Federal dams and reservoirs in the mainstem lower Columbia/Snake River migration corridor between the late 1930s and early 1970s: four on the lower Columbia River (Bonneville, The Dalles, John Day, and McNary Dams) and four on the lower Snake River (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams) (NMFS 2017a).

2.3.1.1.3 Recovery Plan

The ESA recovery plan for SRB steelhead (NMFS 2017a) includes delisting criteria for the DPS, along with identification of factors currently limiting the recovery of the DPS, and management actions necessary for recovery. Biological delisting criteria are based on recommendations by the ICTRT.[79] They are hierarchical in nature, with DPS-level criteria based on the status of natural-origin SRB steelhead assessed at the population level. The plan identifies DPS- and MPG-level biological criteria, and within each MPG, it provides guidance on a target risk status for each population, consistent with the MPG-level criteria. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the DPS will require sufficient improvement in its abundance, productivity, spatial structure, and diversity. Table 2.3-2 summarizes the recovery plan goals and population status as of the most recent status review (NMFS 2016b) for SRB steelhead populations.

Table 2.3-2. Population status as of the most recent status review (NWFSC 2015, NMFS 2016b) and recovery plan target status for SRB steelhead populations (NMFS 2017a).

MPG	Population	Population Status (as of 2016 status review)	Recovery Plan Proposed Target Status	ICTRT Viability Criteria Recommendations Regarding Target Status
Lower Snake	Tucannon River	high risk	viable or highly viable	The basic ICTRT criteria would call for both populations to be restored to viable status and one to highly viable.

[79] The recovery plan also includes "threats criteria" for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

MPG	Population	Population Status (as of 2016 status review)	Recovery Plan Proposed Target Status	ICTRT Viability Criteria Recommendations Regarding Target Status
	Asotin Creek	maintained	viable or highly viable	
Clearwater River	Lower Main Clearwater River	maintained	viable or highly viable	The basic ICTRT criteria would require at least three populations to be viable and one of these highly viable; the rest should meet criteria for maintained. The Lower Mainstem Clearwater population, as the only extant large or very large population, should be viable or highly viable. At least two of the three intermediate-sized populations should be viable or highly viable. At least one A-Index and one B-Index population should be viable.
	South Fork Clearwater River	maintained or high risk	viable or maintained	
	North Fork Clearwater River	extirpated	not part of recovery scenario	
	Lolo Creek	maintained or high risk	viable or highly viable	
	Selway River	maintained	viable or maintained	
	Lochsa River	maintained	viable or highly viable	
Grande Ronde River	Lower Grande Ronde River	maintained	viable or maintained	The basic ICTRT criteria would require at least two populations to be viable, with one highly viable; the rest should meet criteria for maintained. The Upper Grande Ronde mainstem is the only large population and needs to be viable or highly viable.
	Joseph Creek	very low risk	viable, highly viable, or maintained	
	Wallowa River	moderate risk	viable or maintained	
	Upper Grande Ronde River	low risk	viable or highly viable	

MPG	Population	Population Status (as of 2016 status review)	Recovery Plan Proposed Target Status	ICTRT Viability Criteria Recommendations Regarding Target Status
Imnaha River	Imnaha River	moderate risk	highly viable	The basic ICTRT criteria would require the single population in this MPG to be highly viable.
Salmon River	Little Salmon	maintained	viable or maintained	The basic ICTRT criteria would require at least six of the 12 populations to be viable, with at least one of these highly viable; the rest should meet maintained criteria. At least four of the intermediate-size populations should meet viability criteria. At least two of the six viable populations should be B-Index. Spatial structure should be a strong consideration in this large MPG. Populations meeting viability criteria should be spread across the Upper Salmon, Middle Fork, South Fork, and Lower Salmon subbasins. A-Index populations should also be represented in the viable populations. Where possible, the distribution of viable A- and B- Index populations should closely mirror historical (lower-risk) conditions.
	South Fork Salmon River	maintained	viable or highly viable	
	Secesh River	maintained	viable or maintained	
	Lower Middle Fork Salmon River Tributaries	maintained	viable or highly viable	
	Upper Middle Fork Salmon River	maintained	viable or highly viable	
	Chamberlain Creek	maintained	viable or highly viable	
	Panther Creek	high risk	viable or maintained	
	North Fork Salmon River	maintained	viable or maintained	
	Lemhi River	maintained	viable or maintained	
	Pahsimeroi River	maintained	viable or maintained	

MPG	Population	Population Status (as of 2016 status review)	Recovery Plan Proposed Target Status	ICTRT Viability Criteria Recommendations Regarding Target Status
	East Fork Salmon River	maintained	viable or maintained	
	Upper Salmon River	maintained	viable or maintained	

2.3.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within the DPS based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the ICTRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low risk. Generally, each MPG must achieve low risk for the DPS as a whole to be considered no longer threatened or endangered.

Due to difficulties in conducting surveys in much of their range, population-specific abundance estimates for SRB steelhead are available only for two populations (Joseph Creek and the Upper Grande Ronde River), but aggregate counts of steelhead at Lower Granite Dam provide some indication of DPS abundance. In the most recent status review (NMFS 2016b), the abundance of natural-origin steelhead at Lower Granite Dam had increased relative to the prior review: the 2011 to 2014 geometric mean of natural-origin A-Index steelhead at Lower Granite Dam was over twice the corresponding estimate for the prior review, and the updated B-Index geometric mean was over 50 percent higher than for the prior review (NWFSC 2015). No new information was available that would change ratings for spatial structure. Some updated information was available that contributed to evaluating diversity risk, and we anticipate that more information will be available for the next status review, expected in 2021, to better elucidate the contributions of individual hatchery programs and to estimate the number and origin of hatchery fish escaping to spawn in natural areas associated with each population (NWFSC 2015).

As of the most recent status review (NMFS 2016b), the overall status of the SRB steelhead DPS remained threatened, with four of the five MPGs in the DPS not meeting their objectives in the recovery plan. The Grande Ronde MPG was tentatively meeting its recovery plan objectives, which require two of the four populations in the MPG to achieve at least viable status (and one of these achieving highly viable status). The Joseph Creek population was considered highly viable and the Upper Grande Ronde River population tentatively viable. Although average abundance for both populations had dropped from the prior review period, both were still considered at low or very low risk for abundance and productivity. Data were limited for the other two populations in the MPG, but both were provisionally rated as maintained (NWFSC 2015).

The four other MPGs were not meeting their recovery objectives at the time of the most recent status review (NMFS 2016b). In the Lower Snake River MPG, the Tucannon River population was considered at high risk and the Asotin population maintained. The apparently low spawning abundance in the Tucannon River population was attributed to a high overshoot rate of returning adults. Analysis of returning PIT-tagged adults from that population (2005 to 2012 return years) indicated that overshoot rates past the Tucannon River and over Lower Granite Dam often exceed 60 percent (Bumgarner and Dedloff 2015, NWFSC 2015, Keefer et al. 2016).

The Imnaha River MPG contains one population, which must meet highly viable status for recovery (NMFS 2017a). This population was considered at moderate risk in the most recent status review (NMFS 2016b), although there is some evidence that natural production may be exceeding the minimum abundance threshold for viability. There is also evidence that hatchery returns to the population may be concentrated in particular spawning reaches, meaning that there may be substantial production areas with relatively low hatchery-origin spawners. Additional years of information from PIT-tags and/or refinements to the genetic stock identification program should result in improved estimates in future status reviews (NWFSC 2015).

In the Clearwater River MPG, improved information on natural-origin spawner abundance indicated in the most recent status review that the Lower Clearwater, Lochsa River, and Selway River populations had improved in overall status relative to prior reviews, but they were still considered maintained (NMFS 2016b). The South Fork Clearwater and Lolo Creek populations were also tentatively considered maintained, due in part to uncertainties regarding productivity and hatchery spawner composition (NWFSC 2015). In the Salmon River MPG (which includes 12 extant populations and one extirpated population (Panther Creek), all extant populations were considered maintained (NWFSC 2015, NMFS 2016b).

Information from Genetic Stock Identification sampling provided an opportunity to evaluate the relative contribution of B-Index returns within each stock group. No population fell exclusively into the B-Index, although there were clear differences among populations in the relative contributions of the B-Index life-history type (NWFSC 2015). The more specific information available on the distribution of natural returns among stock groups and populations indicated that differences in abundance/productivity status among populations was likely related more to geography or elevation than the morphological forms (i.e., A-Index and B-Index).

Table 2.3-3 lists the MPGs and populations in this DPS and summarizes their abundance/ productivity, spatial structure, diversity, and overall population risk status, based on information in the most recent status review (NWFSC 2015, NMFS 2016b).

Table 2.3-3. SRB steelhead population-level risk for abundance/productivity (A/P), diversity, integrated spatial structure/diversity (SS/D), and overall status as of the most recent status review (NWFSC 2015, NMFS 2016b). Risk ratings ranged from very low (VL) to low (L), moderate (M), high (H), very high (VH), and extirpated (E). Maintained (MT) population status indicates that the population does not meet the criteria for a viable (low risk) population but does support ecological functions and preserve options for recovery of the DPS. "?" reflects uncertainty in the ratings.

Major Population Group	Spawning Populations (Watershed)	ICTRT Minimum Abundance Threshold[1]	A/P Risk Rating	Diversity Risk Rating	Integrated SS/D Risk Rating	Overall Extinction Risk Rating
Lower Snake River	Tucannon River	1,000	H?	M	M	H?
	Asotin Creek	500	M?	M	M	MT?
Grande Ronde River	Lower Grande Ronde River	1,000	insufficient data	M	M	MT?
	Joseph Creek	500	VL	L	L	VL (Highly viable)
	Upper Grande Ronde River	1,500	L	M	M	L (Viable)
	Wallowa River	1,000	H?	L	L	M?
Clearwater River	Lower Clearwater River	1,500	M?	L	L	MT?
	South Fork Clearwater River	1,000	H	M	M	MT?/H?
	Lolo Creek	500	H	M	M	MT/H?
	Selway River	1,000	M?	L	L	MT?
	Lochsa River	1,000	M?	L	L	MT?
	North Fork Clearwater River	NA	E	E	E	E
Salmon River	Little Salmon River	500	M?	M	M	MT?
	South Fork Salmon	1,000	M?	L	L	MT?
	Secesh River	500	M?	L	L	MT?
	Chamberlain Creek	500	M?	L	L	MT?
	Lower MF Salmon	1,000	M?	L	L	MT?
	Upper MF Salmon	1,000	M?	L	L	MT?
	Panther Creek	500	M	M	H	H?
	North Fork Salmon	500	M	M	M	MT?
	Lemhi River	1,000	M	M	M	MT
	Pahsimeroi River	1,000	M	M	M	MT?
	East Fork Salmon	1,000	M	M	M	MT?
	Upper Main Salmon	1,000	M	M	M	MT?
Imnaha	Imnaha River	1,000	M?	M	M	M?

[1] Minimum abundance thresholds represent the number of spawners needed for a population of a given size category to achieve low risk (viability) at a given productivity (ICTRT 2007).

2.3.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the SRB steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. Limiting factors identified in the recovery plan (NMFS 2017a) for this DPS include (in no particular order):

- Tributary habitat degradation: Past and/or present land use hinders SRB steelhead productivity through the following limiting factors: impaired fish passage (e.g., culverts, water diversions, and weirs at hatchery facilities); reduced stream complexity and channel structure; excess fine sediment; elevated summer water temperatures; diminished streamflow during critical periods; reduced floodplain connectivity and function; and degraded riparian conditions.
- Estuarine habitat degradation: Past and current land use (including dredging, filling, diking, and channelizing of lower Columbia River tributaries) and alterations to Columbia River flow regimes by reservoir storage and release operations have reduced the quality and quantity of estuarine habitat.
- Hydropower: Federal hydropower projects in the lower Snake and Columbia River mainstem affect juvenile and adult SRB steelhead, which must pass up to eight mainstem dams. The fish are also affected to a lesser degree by the management of water released from the Hells Canyon Complex on the middle Snake River, Dworshak Dam on the North Fork Clearwater River, and other projects, including upper basin storage reservoirs in the U.S. and Canada. Limiting factors include those related to dam passage mortality; loss of habitat due to conversion of riverine habitat to slower moving reservoirs with modified shorelines; and changes in temperature regimes due to flow modifications in all mainstem reaches.
- Harvest: Direct and indirect effects associated with past and present fisheries continue to affect the abundance, productivity, and diversity of SRB steelhead. However, while harvest-related mortality contributed significantly to the species' decline, harvest impacts have been reduced substantially and have remained relatively constant in recent years.
- Hatchery programs: Hatchery programs can improve the abundance of steelhead populations with low abundance and support reintroduction into areas where they have been blocked or extirpated. However, hatchery propagation also poses risks to natural-origin salmon. These risks include genetic risks, reduced fitness, altered life-history traits, increased competition for food and habitat, amplified predation, and transferring of diseases.
- Predation: Anthropogenic changes have altered the relationships between salmonids and other fish, bird, and pinniped species. Predation by pinnipeds, birds, and piscivorous fish in the mainstem Columbia and Snake Rivers and some tributaries has increased to the point that it is a factor limiting the viability of SRB steelhead.
- Additional factors include exposure to toxic contaminants, and the effects of climate change and ocean cycles.

In its most recent status review, NMFS (2016b) noted that:

- Improvements had been made in tributary and estuary habitat conditions due to restoration and protection efforts, but habitat concerns remain throughout the Snake River basin, particularly in regard to streamflow, floodplain management, and water temperature.
- Changes to hydropower operations and passage had increased juvenile survival rates.
- In late July and September 2013, low summer flows combined with high air temperatures and little wind created thermally stratified conditions in Lower Granite reservoir and the adult ladder, disrupting fish passage for more than a week. The events resulted in approximately 12 percent of the migrating steelhead failing to pass Lower Granite Dam.
- The adoption of the 2008 to 2017 *U.S. v. Oregon* Management Agreement had, on average, reduced impacts of freshwater fisheries to all Snake River ESUs and DPSs.
- SRB steelhead hatchery programs were being reviewed to determine, among other things, where and to what extent hatchery steelhead were interacting with natural populations. The practice of releasing steelhead into mainstem areas where they are difficult to monitor and manage had been reduced since the previous review.
- New information indicated that avian and pinniped predation on SRB steelhead had increased since the previous status review.
- Regulatory mechanisms had generally improved since the previous status review.
- Uncertainty regarding the long-term impacts of climate change and the ability of SRB steelhead to adapt added additional risks to species recovery.
- Key protective measures included continued releases of cool water from Dworshak Dam during late summer, continued flow augmentation to enhance flows in the lower Snake River in July and August, and continued efforts to improve adult passage at Lower Granite Dam.

2.3.1.1.6 Information on Status of the Species since the 2016 Status Review

The best scientific and commercial data available with respect to the adult abundance of SRB steelhead indicates a substantial downward trend in the abundance of natural-origin spawners at the DPS-level from 2014 to 2019 (Figure 2.3-2). Population-level estimates of natural-origin and total (natural- plus hatchery-origin) spawners through 2018 or 2019 are shown for three populations of SRB steelhead in Table 2.3-4. The number of natural-origin spawners in the Upper Grande Ronde Mainstem population appears to have been at or above the minimum abundance threshold established by the ICTRT (shown in Table 2.3-3), while the Tucannon River and Asotin Creek populations have remained below their respective thresholds). The 2019 abundance level for the Tucannon River population was lower than the most recent 5-year geomean.[80]

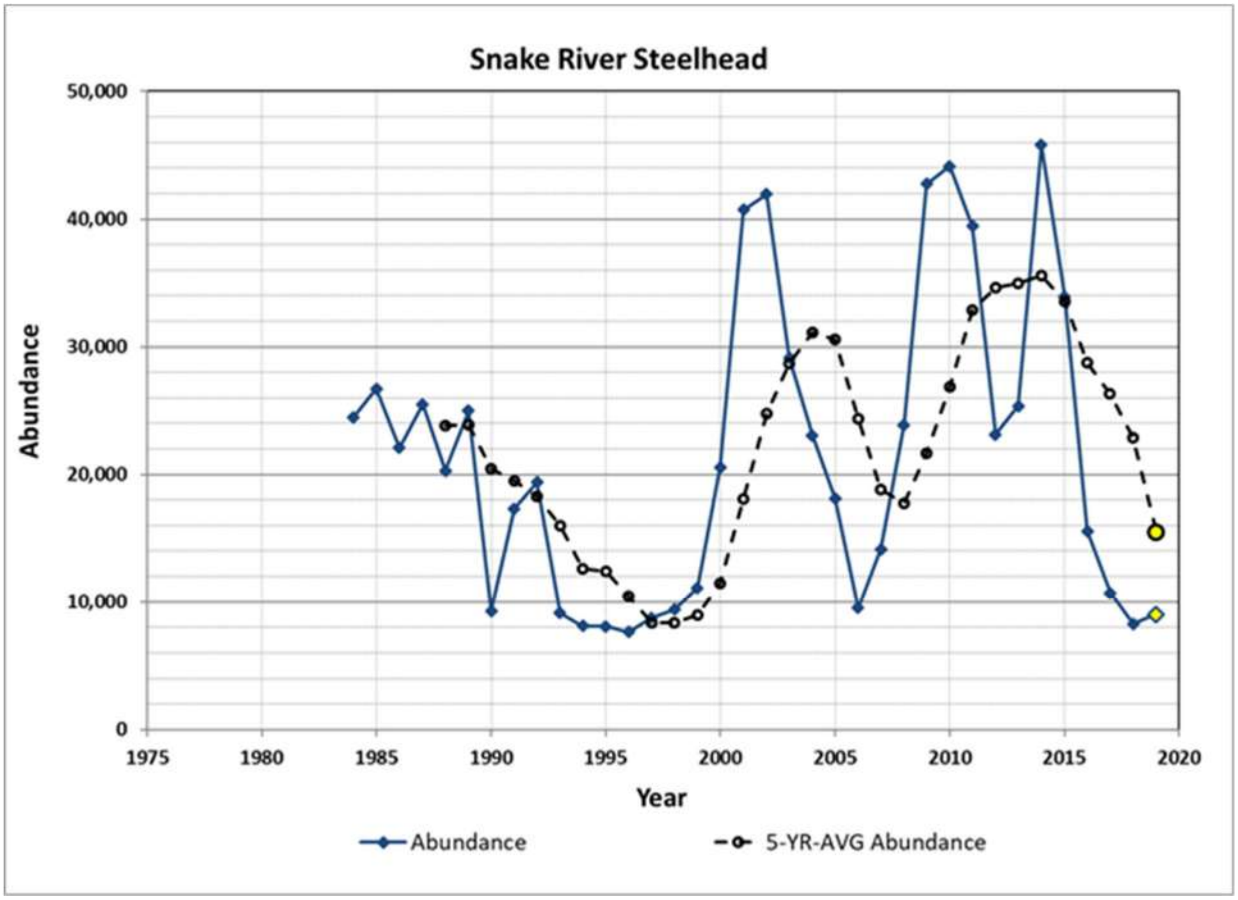

Figure 2.3-2. Annual abundance and 5-year average abundance estimates for the Snake River steelhead DPS (natural-origin fish only) at Lower Granite Dam from 1984–1985 to 2018–2019. Data for year X include passage counts occurring from July 1 of year X to June 30 of year X+1. Data for year 2019–2020 are a projection based on passage counts through December 31, 2019, average percent passage that occurs in year X, and average percent natural-origin fish. Data source: 2020 Joint Staff Report on Stock Status and Fisheries (ODFW and WDFW 2020) and Hebdon (2020).

[80] The upcoming status review, expected in 2021, will include population-level adult returns through 2019, and will add a new rolling 5-year geomean, for 2015-2019. Because the 2014 adult returns represented a peak at the DPS level, the negative percent change between the 2015-2019 and 2014-2018 geomeans will likely be greater than that shown in Table 2.3-4 between the 2014-2018 and 2009-2013 geomeans, at least for some populations.

Table 2.3-4. 5-year geometric mean of natural-origin spawner counts for SRB steelhead. Number in parenthesis is the 5-year geometric mean of total spawner counts including hatchery fish. "% change" is a comparison between the two most recent 5-year periods (2014–2018 compared to 2009–2013). "NA" means not available. At the time of drafting this opinion, 2019 data were available only for the Tucannon River population. Source: Williams (2020a, 2020c).

Population	MPG	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
Grande Ronde	Upper Grande Ronde River Mainstem	900 (1173)	1575 (1898)	1232 (1454)	1067 (1073)	2689 (2724)	1786 (1799)	-34 (-34)	NA
Lower Snake	Tucannon River	NA	NA	NA	1442 (1988)	438 (1576)	264 (920)	-40 (-42)	117 (592)
Lower Snake	Asotin Creek	253 (444)	288 (439)	574 (648)	489 (542)	778 (787)	424 (427)	-46 (-46)	NA

The populations for which data are shown in Table 2.3-4 are surveyed by monitoring at weirs, conducting mark-recapture studies, PIT-tag detections, or redd counts. For many other SRB steelhead populations, spawning ground surveys are not feasible due to high spring flows that would wash out weirs and low visibility that precludes redd counts. The IDFG, Columbia River Inter-Tribal Fish Commission (CRITFC), and the NWFSC therefore collect tissue samples from adult steelhead trapped at Lower Granite Dam and assign these fish to genetic stocks by comparing them to samples taken inside the boundary of each spawning population (Table 2.3-5). The genetic stock identification (GSI) groups are broader than spawning populations, but fit within the MPGs. The most recent 5-year geometric means indicate large decreases in natural-origin abundance for most of the genetic stocks/MPGs, with a smaller decrease for the Upper Clearwater genetic stock group. Numbers for 2019 were much lower than the 2014 to 2018 geomean.

Table 2.3-5. 5-year geometric means of natural-origin abundance for genetic stocks of SRB steelhead at approximately the MPG level. Genetic Stock Identification (GSI) was based on a comparison of samples taken from returning adults at Lower Granite Dam to data from the Snake River Steelhead Natural Origin Abundance and Stock Composition at Lower Granite Dam database (Sources: Williams 2020b, c).

GSI Group	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
Lower Salmon	704	337	832	709	1403	580	-59	154
Middle Fork Salmon	1566	749	1852	1578	3246	1643	-49	454
South Fork Salmon	762	364	901	767	1441	831	-42	210
Upper Salmon	2809	1344	3320	2829	5388	2860	-47	1,035

GSI Group	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
Lower Clearwater	1586	759	1875	1597	2836	1940	-32	454
South Fork Clearwater	1271	608	1502	1280	2750	1201	-56	541
Upper Clearwater	1373	657	1623	1384	2415	2024	-16	707

These data show that SRB steelhead MPGs generally increased in abundance after the 1990s, but experienced reductions during the more recent period when hydrosystem operations, the overall availability and quality of tributary and estuary habitat, and hatchery practices were relatively constant or improving, but ocean conditions were poor.[81] Although these conditions (e.g., temperature and salinity, coastal food webs) appear to have been more favorable to juvenile steelhead survival in 2018, juveniles were still affected by recent warming trends. Increased numbers of sea lions in the lower Columbia River in the last 10 years could also be a contributing factor to the recent reductions.

NMFS will evaluate the implications for viability risk of these more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure as well as the updated estimates of abundance shown in Tables 2.3-4 and 2.3-5.

2.3.1.2 Status of Critical Habitat

NMFS designated critical habitat for SRB steelhead to include all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to its confluence with the Snake River, as well as all river reaches of the mainstem Snake River upstream to Hells Canyon Dam (50 CFR 226.212(o)). Of 263 designated HUC5[82] watersheds in the Columbia River and its tributaries, NMFS (2005b) gave 216 a high, 39 a medium, and 8 a low rating for their value to the conservation (i.e., recovery) of the species. All mainstem Columbia and Snake River reaches, including those in the Columbia River estuary, were given high ratings because they connect

[81] Many factors (e.g., higher summer temperatures, lower late summer flows, low spring flows, etc.) affect the ability of tributary habitat to produce juvenile migrants (capacity) each year. Recent drought and temperature patterns may have had a negative effect on tributary habitat productivity, and as a result, lower than average juvenile production may have contributed in some years to downturns in adult abundance.

[82] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country. A HUC5 is a five-unit (five 2-digit numbers) code. Examples are “Salmon River-Redfish Lake Creek” (1706020102) in the upper Salmon River basin, Idaho; “Wenatchee River—Icicle Creek” (1709000501) in the Wenatchee Basin, Washington.

every population with the ocean and are used by rearing/migrating juveniles and migrating adults.

The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b), as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.
- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These

features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.

- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case with freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The complex life cycle of SRB steelhead gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas, and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead, rely on limited energy stored to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005a). In the following sections we discuss the current status of the functioning of PBFs for critical habitat in the Interior Columbia and Lower Columbia River Estuary Recovery Domains.

2.3.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia Recovery Domain, which includes the Snake River basin, for SRB steelhead. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Critical habitat throughout much of the Interior Columbia Recovery Domain has been degraded by intense agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems for critical habitat in developed areas. Restoration activities addressing tributary habitat quality and complexity, tributary and mainstem migration barriers, water quality, and excessive predation have improved the baseline condition for PBFs in some locations.

SRB steelhead have lost access to large blocks of their historical habitat. Dam construction blocked or hindered fish access to historical habitat in major tributaries. Steelhead populations in the North Fork Clearwater River subbasin were eliminated in the early 1970s following construction of Dworshak Dam. In the Salmon River basin, Sunbeam Dam, constructed on the Salmon River below the mouth of the Yankee Fork (RM 368) in 1910, was a serious impediment to migration of anadromous fish and may have been a complete block in at least some years before its partial removal in 1934 (Waples et al. 1991). The construction of the Hells Canyon Complex of dams eliminated access to several likely production areas in Oregon and Idaho, including the Burnt, Powder, Weiser, Payette, Malheur, Owyhee, and Boise River basins (NMFS 2017a). Many smaller dams, and some temporary dams, were also built on tributaries at this time without fish passage facilities and had the same effects, though on much smaller scales. The loss of this historical habitat significantly reduced the spatial structure that was once available to the species.

Construction of large hydropower and water storage projects associated with the CRS further affected salmonid migratory conditions and survival rates. As noted above, the production of SRB steelhead was especially impacted by the development of eight major Federal dams and reservoirs in the mainstem lower Columbia/Snake River migration corridor between the late 1930s and early 1970s. Hydrosystem development also modified natural flow regimes, resulting in warmer late summer and fall water temperatures. Changes in fish communities led to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines and juvenile bypass systems, have also killed outmigrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented improvements in the juvenile and adult migration corridors, including 24-hour volitional spill, improved surface passage routes, improved juvenile bypass systems, and predator management measures. These measures are ongoing, and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

Many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain are over-allocated, with more allocated water rights than existing stream flow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a major limiting factor for SRB steelhead (NMFS 2017a).

Summer water temperatures are elevated in many tributary stream reaches across the Snake River basin and exceed water quality standards (NMFS 2017a). The elevated water temperatures restrict salmonid use of some historically suitable habitat areas, particularly summer rearing and migration habitat. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat. They can negatively impact critical habitat and the organisms associated with these areas.

2.3.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat has also been designated for SRB steelhead in the lower Columbia River estuary. For the purpose of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained the dynamic environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels; marsh and riparian habitats have been filled and diked; and causeways have been constructed that restrict the position of tributary confluences.

Over time, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of the historical variability in mainstem flows in the lower river through storage and release operations at upstream reservoirs may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has reduced the delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The combined effect of these changes is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs, and thus the conservation value of critical habitat for SRB steelhead within the action area, are discussed in more detail in the Environmental Baseline section, below.

2.3.1.3 Climate Change Implications for SRB Steelhead and Critical Habitat

One factor affecting the rangewide status of SRB steelhead and aquatic habitat is climate change. The USGCRP[83] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[84] as follows:

Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.

- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, earlier emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003, Crozier et al. 2008a, Martins et al. 2012, Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to

[83] http://www.globalchange.gov

[84] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead include:

- Direct effects of increased water temperatures on fish physiology.
- Temperature-induced changes to stream flow patterns, which can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.
- Alterations to freshwater, estuarine, and marine food webs, which alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity, which have changed the abundance and productivity of fish resources.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Crozier et al. (2019) assessed SRB steelhead as having high overall vulnerability to the effects of climate change based on an analysis of the DPS's sensitivity (high) and exposure (high). Further, this DPS was determined to have moderate adaptive capacity (Crozier et al. 2019).[85] The high sensitivity score was assigned in part because of the DPS's high sensitivity at the adult freshwater stage. Most populations are subject to high stream temperatures during the upstream migration and pre-spawn holding phases (Wade et al. 2013). Moreover, for populations in Lower Snake River tributaries, the presence of mainstem dams (particularly Lower Granite Dam) may exacerbate straying. Exposure to increased stream temperature and summer water deficit during the upstream migration and holding periods were also high to very high, indicating a high climate change vulnerability for SRB steelhead in the adult freshwater stage.

Although detailed information on ocean distributions for Columbia River steelhead is not available, past studies suggest that steelhead from Pacific coastal systems generally occur in the Gulf of Alaska and the subarctic waters south of the Aleutian Islands (Light et al. 1989). Abdul-Aziz et al. (2011) developed spatially explicit representations of open ocean thermal habitat for

[85] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results.

steelhead. They found that under a multimodel ensemble average of climate model outputs using the A1B emissions scenario, summer habitat area declined by 36 percent for the 2080s, with the largest habitat losses in the northeast Pacific Ocean. Wintertime habitat area losses were 2 percent, with reductions at the southern end of the historical range largely offset by habitat area gains in the Bering Sea and Sea of Okhotsk.

Whether a general northward and westward displacement of the most frequently observed thermal open ocean habitat will have substantial impacts on the life-cycle, productivity, or spawning distribution of these steelhead is not known. A recent study of smolt-to-adult survival trends found similar patterns in annual marine survival for stocks within regional groupings for Puget Sound, British Columbia and coastal Washington and Oregon (Kendall et al. 2017). Such patterns suggest that marine/estuarine factors associated with the point of ocean entry may be more important determinants of year-class survival for steelhead than general conditions in the adult ocean range.

Despite moderate to high exposure scores for flooding, stream temperature, and summer water deficit, sensitivity scores were ranked low to moderate for the early life-history (egg incubation) and juvenile freshwater stage. Sensitivity of egg incubation was rated low because stream temperature and flows are generally well within tolerance limits. Therefore, vulnerability of SRB steelhead is likely somewhat lower at the egg incubation and juvenile rearing stages. Sensitivity scores were low to moderate for the estuary stage. Exposure was ranked high for sea surface temperature, with low exposure to ocean currents, upwelling, and sea level rise. Sensitivity was ranked moderate for the marine stage.

The overall rating for adaptive capacity was moderate for SRB steelhead, but there was also a large number of low scores. This DPS could have some potential for shifts in adult return and upstream migration timing to avoid peak late summer temperatures, but that may lead to increased negative effects from lower flows. For populations in high temperature or low flow areas, there are limited opportunities to shift juvenile rearing patterns to avoid climate change effects.

2.3.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima are likely to be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce fitness for salmonids, including for SRB steelhead (Beechie et al. 2013, Wainwright and Weitkamp 2013, Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a, Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012, Whitney et al. 2016).

2.3.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location (Crozier et al. 2008b, Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b, Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely that this increasingly variable flow is detrimental to multiple salmon and steelhead populations in the Columbia River Basin.

The effects of climate change on stream ecosystems are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes are likely to lead to shifts in the distributions of native species and facilitate establishment of exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016, Rehage and Blanchard 2016). How juvenile native species will fare as part of “hybrid food webs,” which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.3.1.3.3 Estuarine Effects

In estuarine environments, the two greatest concerns associated with climate change are rates of sea-level rise and water temperature warming (Wainwright and Weitkamp 2013, Limburg et al. 2016). Estuaries will be affected directly by sea-level rise; as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010, Wainwright and Weitkamp 2013, Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas

(Verdonck 2006, Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species and life-history types are highly reliant on estuarine wetlands for rearing, many populations use them extensively (Jones et al. 2014). Others such as SRB steelhead, benefit from the influx of prey from the floodplain to the mainstem migration corridor (Johnson et al. 2018, PNNL and NMFS 2018, 2020).

2.3.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010, Asch 2015, Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years. For example, range extensions were documented in many species from southern California to Alaska during unusually warm water associated with the marine heatwave known as “the blob” in 2014 and 2015 (Bond et al. 2015, Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002, Fisher et al. 2015). The potential for SRB steelhead to shift their distribution north was discussed above. The frequency of extreme conditions such as those associated with marine heatwaves or El Niño events is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015, Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with current models. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm ocean conditions, suggesting that, at a minimum, prey availability and prey quality, “bottom-up” drivers of growth and survival, may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem[86] (Bograd et al. 2009, Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Peterson et al. 2014, Black et al. 2015). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the

[86] The California Current moves southward along the western coast of North America, beginning off southern British Columbia and ending off the southern Baja California Peninsula.

timing of salmon entering the ocean, and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007, Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in Alaska salmon productivity and survival (Mantua et al. 1997, Martins et al. 2012). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009, Martins et al. 2012). However, more recent information indicates that Alaska salmon, which have historically contrasted with southern populations by benefitting from warm phases of the PDO, no longer have a positive correlation with winter sea-surface temperature (Litzow et al. 2018) and are more synchronized with southern populations (Ohlberger et al. 2016). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells, and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon is likely to be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015, Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.3.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change in general, including in the Pacific Northwest. The indirect effects of climate change are also uncertain, including whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013, Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. Moreover, impacts of climate in one habitat can have carry-over effects in later life stages. For example, warmer stream and river temperatures may lead to earlier outmigration and potential mismatches between ocean entry and peak prey availability or predator dynamics. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to a range of potential future outcomes.

2.3.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For SRB steelhead, we focus our description of the environmental baseline on areas where juveniles and adults are most exposed to the effects of the proposed action. We also consider the broader action area, including spawning and rearing areas, both because the Action Agencies propose to conduct habitat restoration actions in these subbasins and because these areas provide important context for understanding the effects of the proposed action. The area in which SRB steelhead are most exposed to the effects of the proposed action includes all waters within the Columbia River from the mouth and plume[87] upstream through the lower Snake and in the Grande Ronde, Clearwater, and Salmon River subbasins where SRB steelhead are present. This includes all waters impounded by Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower

[87] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

Monumental, Little Goose, and Lower Granite Dams and tributary confluences in this reach to the extent they have been inundated by mainstem reservoirs or are affected by flow management.

2.3.2.1 Mainstem Habitat

Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., smallmouth bass, walleye, channel catfish, and invertebrates, etc.), and other human activities that have degraded water quality and habitat.

2.3.2.1.1 Seasonal Flows

On the mainstem Snake[88] and Columbia Rivers, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.3-3). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

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[88] The effects of the operation and maintenance of 10 Reclamation projects and two related actions in the upper Snake River above Brownlee Reservoir, including the 2004 Nez Perce Water Rights Settlement and the Snake River Water Rights Act of 2004 (for a 30-year period through 2034; USBR 2007), underwent consultation in 2008 (NMFS 2008a, b).

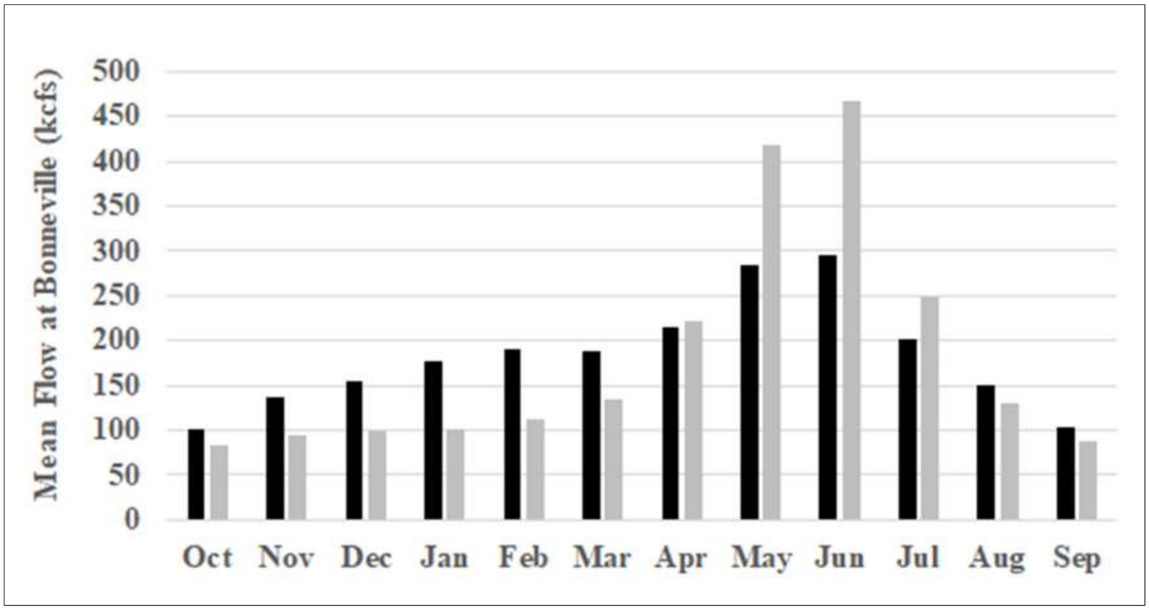

Figure 2.3-3. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[89] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs, including SRB steelhead, remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year (Table 2.3-6). This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released

[89] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile SR spring/summer Chinook salmon and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

Table 2.3-6. Seasonal flow objectives and planning dates for the mainstem Columbia and Lower Snake Rivers. NA indicates that there is not a flow objective for the season at these projects.

Location	Spring		Summer	
	Dates	Objective (kcfs)	Dates	Objective (kcfs)
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100[a]	6/21 to 8/31	50 to 55[a]
Columbia River at McNary Dam	4/10 to 6/30	220 to 260[a]	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 to 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160[b]	NA	NA

[a] Objective varies based on actual and forecasted water conditions.

[b] Objective varies according to water volume forecasts and is for chum salmon (spawning period is approximately November 1 through December and protection flow objectives are based on redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

Seasonal flow objectives for improving the migration and survival of spring and summer juvenile migrants are based on water supply forecasts; however, mean seasonal flows in the past did not always achieve the flow objectives when measured as a seasonal average flow. From 1998 to 2019, seasonal spring flow objectives were met or exceeded during 81 percent of years at McNary Dam and during 48 percent of years at Lower Granite Dam. For the years when the spring flow objectives were not met, the average seasonal flow was 88 percent of the spring flow objective at McNary Dam and 78 percent of the spring flow objective at Lower Granite Dam. Across all years, the average percentage of the spring flow objective obtained was 113 percent at McNary Dam and 101 percent at Lower Granite Dam. Achieving these seasonal flow objectives provides multiple benefits for smolts in the migration corridor, estuary, and plume. Higher spring flow helps reduce fish travel time, increases juvenile access to shallow water habitat along the river banks, increases the flux of invertebrate prey to shoreline habitat, increases turbidity (which can reduce predation on juvenile migrants), and increases the size of the Columbia River plume, which is a key transition corridor for smolts to the nearshore ocean environment. Conversely, when seasonal flow objectives are not met, juvenile survival may be reduced via these same pathways of ecological effects.

From 1998 to 2019, summer flow objectives were met or exceeded during 14 percent of years at McNary Dam and during 18 percent of years at Lower Granite Dam. For the years when the summer flow objectives were not met, the average seasonal flow was 74 percent of the summer flow objective at McNary Dam and 66 percent of the summer flow objective at Lower Granite

Dam. Across all years, the average percentage of the summer flow objective obtained was 85 percent at McNary Dam and 79 percent at Lower Granite Dam. The benefits provided by attaining summer flow objectives, and potential impacts associated with not meeting them, are the same as those previously described for the spring flow objectives.

Recommendations on when to manage flows for the benefit of juvenile passage are made by the TMT during the juvenile migration season. These recommendations are informed by the status of the juvenile migration, water supply forecasts, river flow conditions, and river flow forecasts during the juvenile migration season.

2.3.2.1.2 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult SRB steelhead is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of SRB steelhead salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Snake and Columbia Rivers on salmon and steelhead survival is a concern; because of temperature standard exceedances, both rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges such as cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

Since the mid-1990s, the Corps has released up to 1.2 million acre-feet of cool water from Dworshak Dam annually on the North Fork Clearwater River to reduce temperatures and enhance flows in the lower Snake River from June or July to September. Operators manage releases from Dworshak Dam so that water temperature at the tailrace of Lower Granite Dam does not exceed 68°F (20°C). This action reduces temperatures in the lower Clearwater River, and the Snake River from the confluence with the Clearwater River to at least Lower Monumental Dam, but has little to no discernible effect on temperature in the Columbia River downstream of the Snake River confluence. Even with the flow augmentation from Dworshak Dam for cooling, temperature criterion exceedances occur frequently at Little Goose, Lower Monumental, and Ice Harbor Dams from mid-July to mid-September (EPA 2020).

The releases from Dworshak Dam cool the lower Clearwater River and Lower Granite Reservoir substantially, although the cooler water is denser and sinks to the bottom, causing vertical stratification of the reservoir. As this water flows downstream, warmer surface water mixes with the cooler, deeper water as it passes through turbines and spillbays at Lower Granite Dam and each subsequent Snake River dam until the cooling effect becomes attenuated below the tailrace of Ice Harbor Dam (NMFS 2008a, 2017a). Figure 2.3-4 depicts this downstream attenuation during the high temperature conditions in 2015. Temperatures were warmest at the Anatone Gage on the Snake River upstream of Lower Granite Reservoir before it was influenced by cooler water from Dworshak Dam. Temperatures were coolest at the Peck Gage on the Clearwater River below Dworshak Dam, and tailrace temperatures proceeding downstream at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams increased at each project. Thus, even in an unusually warm, low-flow year, the cool-water releases from Dworshak Dam substantially improved the summer migration conditions for adult summer Chinook salmon in the lower Snake River compared to the high temperatures that would have been present at these projects without flow augmentation for temperature control. The difference in temperatures after mid-June observed at the Anatone Gage without the cooling effect from Dworshak Dam releases (approximately 22°C to 24°C) compared to that at Lower Granite Dam with the coldwater releases from Dworshak Dam (approximately 18°C to 21°C) is biologically significant; the Oregon and Washington temperature standard for migrating adult Chinook salmon both are 20°C (daily maximum or 7-day average daily maximum; EPA 2020), above which survival and reproductive success are expected to decline.

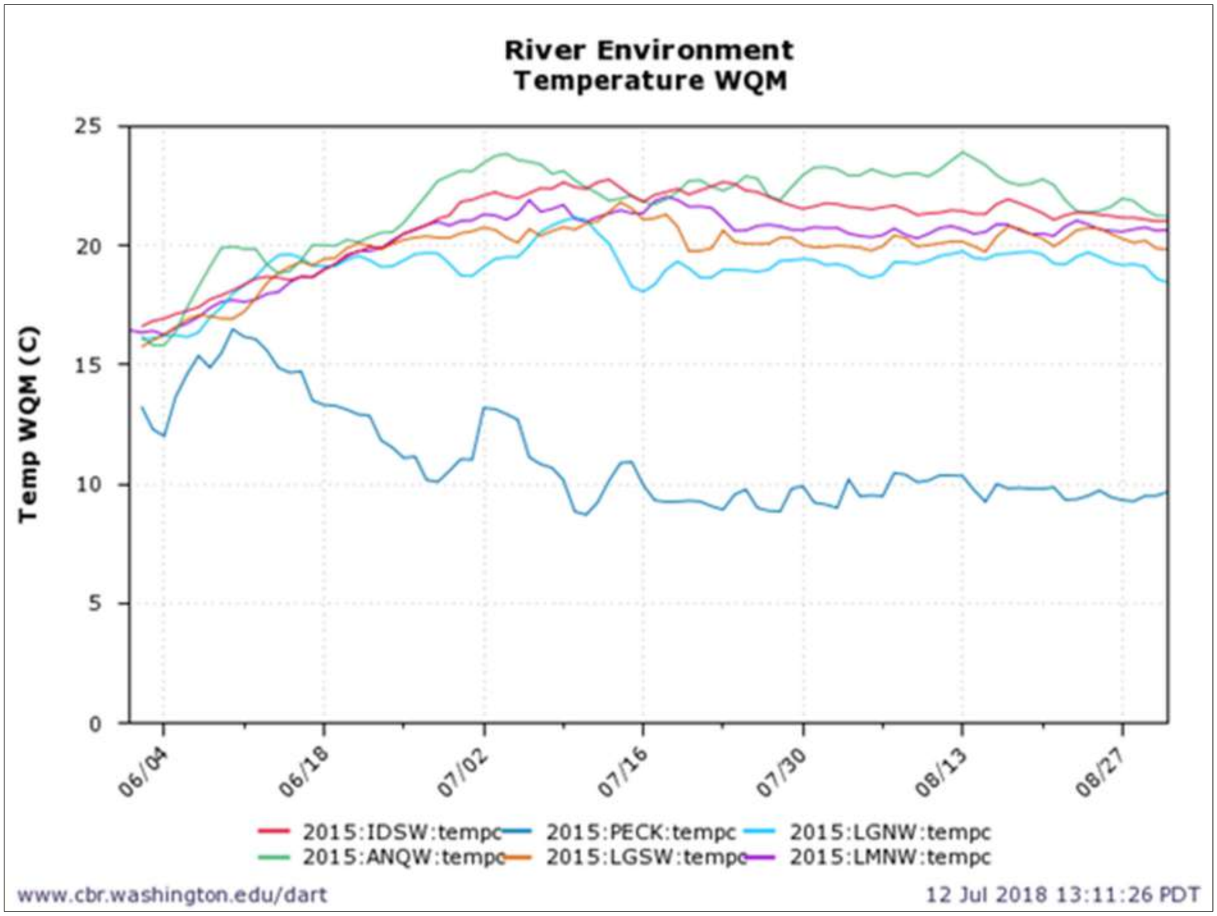

Figure 2.3-4. Water temperature at the Anatone Gage on the Snake River upstream of the Clearwater River confluence (ANQW, green); the Peck Gage on the lower Clearwater River (PECK, dark blue); and, in order from upstream to downstream located below the Clearwater River confluence, the tailrace temperatures at Lower Granite (LGNW, light blue), Little Goose (LGSW, orange), Lower Monumental (LMNW, purple), and Ice Harbor (IDSW, red) dams during summer, 2015.

The Corps also operates fishway exit cooling pumps at Lower Granite and Little Goose Dams to minimize adult passage delays associated with localized temperature differentials between these adult ladders and project forebays, which can potentially improve adult survival rates.

PIT-tag data (DART 2020l) indicate that the middle 90 percent of SRB steelhead adults historically pass Bonneville Dam in July, August, and September. Warmer August and September mainstem temperatures could therefore negatively affect adult SRB steelhead that migrate in the summer. Exposure to elevated temperatures in the Columbia River from its mouth to its confluence with the Snake River, is greatest for adult SRB steelhead migrating in late summer when water temperatures are highest (Keefer et al. 2016, Keefer and Caudill 2017).

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the middle and lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with Federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995a). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam except The Dalles Dam. Biological monitoring (smolts sampled from the juvenile bypass systems at many mainstem dams) shows that the incidence of observable GBT symptoms in both migrating smolts and adults remains between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces.[90] When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[91] Under recent operations (2008 to 2019), exposure to elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June, affecting most SRB

[90] Monitoring at the Lower Granite Dam trap in 2018 (experiencing higher court-ordered spill operations) and in 2019, showed that GBT and headburn symptoms on adult steelhead and Chinook) were similar in prevalence relative to past years (Corps' Lower Granite Adult Trap database accessed on December 10, 2019, and Ogden 2018b). Headburn refers to lesions and ulcers on the heads and jaws of migrating adults that can result from contact with concrete and other structures at dams, and which can increase prespawn mortality (Neitzel et al. 2004).

[91] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, organisms two meters below the surface would effectively experience 100 percent TDG saturation.

steelhead juveniles. Monitoring data from 1998 to 2018 indicate that TDG did not increase instantaneous mortality rates for juvenile steelhead in the CRS (CSS 2019).

The states of both Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia and the four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

Sediment Transport

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

NMFS completed formal consultation for the Channel Maintenance Dredging in the lower Snake and Clearwater Rivers (WCR-2014-1723) on November 14, 2014. This action included dredging material in the Snake and Clearwater Rivers at four sites: 1) the downstream navigation lock approach at Ice Harbor Dam, 2) the Federal navigation channel in the Snake and Clearwater Rivers confluence area, 3) the berthing area for the Port of Clarkston, Washington, and 4) the berthing area for the Port of Lewiston, Idaho. The Corps also issued regulatory permits for dredging at commercial ports and berths operated by local port districts or private companies in Clarkston, Washington, and Lewiston, Idaho. Most of these non-Federal navigation areas consisted of arterial channels leading from the main Federal navigation channel to the port or berth, as well as the areas at the port or berth used for loading, unloading, mooring, or turning around. During in-water work, short-term adverse effects on aquatic resources included elevated turbidity, suspension of chemicals, harassment and entrainment of fish, and disruption of benthic organisms that serve as prey for juvenile salmon. The dredged material was disposed of inriver as fill to construct a shallow-water bench for juvenile fish habitat at Knoxway Bench (RM 116) immediately upstream of Knoxway Canyon.

In 2005 to 2006, the Corps deposited approximately 420,000 cubic yards of sand and silt at the upstream end of the Knoxway Bench site. The Corps then shaped the dredged material to create an estimated 3.7-acre shallow-water habitat bench that could be used by juvenile salmonids, particularly juvenile SR fall Chinook salmon. Post-project monitoring for the 2006 effort by the Corps confirmed that juvenile salmonids have been and are using the site for resting and rearing. With the dredging conducted under the 2014 biological opinion, the materials were deposited downstream from the bench created in 2006, and extended riverward of the existing shoreline. The new material formed a uniform, gently sloping shallow-water bench along roughly 2,500 linear feet of shoreline. This feature added approximately 11.4 acres of shallow-water habitat with features preferred for foraging by juvenile salmonids, particularly fall Chinook salmon. In sum, these activities should have little or no negative effect on juvenile or adult SRB steelhead, and should increase the amount of available rearing habitat.

2.3.2.1.3 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of SR spring/summer Chinook salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[92] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

The EPA is proposing to issue National Pollutant Discharge Elimination System (NPDES) permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[93] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville), backwash strainer water on cooling water intakes. Most pollutant discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and instead result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

[92] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[93] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 milligrams per liter [mg/L]) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.3.2.1.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adults that are migrating past the dams or overwintering within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Few to no juvenile steelhead have been affected by these activities, because they predominantly migrate from April to June.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult SRB steelhead has likely resulted in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes have minimized the impacts.

2.3.2.1.5 Adult Migration/Survival

Adult SRB steelhead must migrate from the ocean, upstream through the estuary, and pass up to eight mainstem dams and reservoirs to reach their spawning areas, except for the Tucannon River steelhead population in the Lower Snake River MPG, which passes six mainstem dams. Factors that affect the survival rates of migrating adults include fish condition, harvest (either reported or unreported), dam passage (adults must find and ascend ladders and reascend the ladders if they fall back through spillways or other routes), straying (either naturally or as a result of impaired homing stemming from transport or other factors), pinniped predation, and temperature and flow conditions that can increase energetic demands of migrating fish (NMFS 2008a, Keefer et al. 2016, Keefer and Caudill 2017). Increased fallback is related to lower conversion rates to natal tributaries for adult salmonids (Keefer et al. 2005, Crozier et al. 2014).

Many summer migrating adults from the Tucannon River overshoot their natal stream and pass upstream of Little Goose Dam and Lower Granite dams. Some of these fish migrate downstream through the dams to reach the Tucannon River after water temperatures have cooled and summer spill has ended. The survival rates of these individuals are reduced because they are passing downstream through the dams via juvenile bypasses and turbine units, which negatively affects the abundance and productivity of the Tucannon River population. A study to assess the efficacy of operating a surface passage route to provide safe and effective downstream passage for Middle Columbia River steelhead at McNary Dam began in the fall of 2019. The results of this study could inform future operations to improve migration conditions outside the juvenile spill season.

PIT-tag detectors placed in adult ladders at the mainstem dams provide a unique ability to monitor the upstream survival of adults that were tagged as juveniles.[94] Starting with the number of adults detected at Bonneville Dam, minimum survival estimates can be derived to detectors at upstream dams. Termed “conversion rates,” these survival estimates are adjusted for reported harvest and the expected rate of straying of natural-origin adults. Figure 2.3-5 depicts minimum estimated survival rates for SRB steelhead from Bonneville Dam to McNary Dam (three reservoirs and dams) and to Lower Granite Dam (seven reservoirs and dams) during 2009 to 2018, years that include recent hydropower operations and harvest rates within the “zone 6” fishery (as designated in the *U.S. v. Oregon* Management Agreements).

As shown in Figure 2.3-5, the 10-year average (2009 to 2018) minimum survival estimate for SRB steelhead adults from Bonneville to McNary Dams is 93.8 percent (range of 90.1 to 98.8 percent).[95] The 10-year average minimum survival estimate from Bonneville to Lower Granite Dam is 87.6 percent (range of 81.2 to 94.1 percent).

These survival estimates account for total losses from the dams and reservoirs as well as any losses in these reaches resulting from elevated temperatures, disease, injury, or other natural causes. Expressed on a “per project” basis, about 97.6 percent of adult SRB steelhead are surviving passage through each project (dam and reservoir) in the lower Columbia River after accounting for reported harvest and natural stray rates. From Bonneville to Lower Granite Dams, per-project survival rates are averaging around 98.0 percent.

[94] Using only known origin fish that were not transported as juveniles. The numbers are adjusted for reported harvest and natural stray rates.

[95] Conversion rates close to, or higher than, 100 percent are possible if estimates of harvest rates (or natural rates of straying) are higher than what actually occurred in a given year (biased high). Conversely, if harvest rates are underestimated, the resulting conversion rate estimates would be biased low. For this analysis, 100 percent was used as a maximum value for calculating the ten-year average survival estimate.

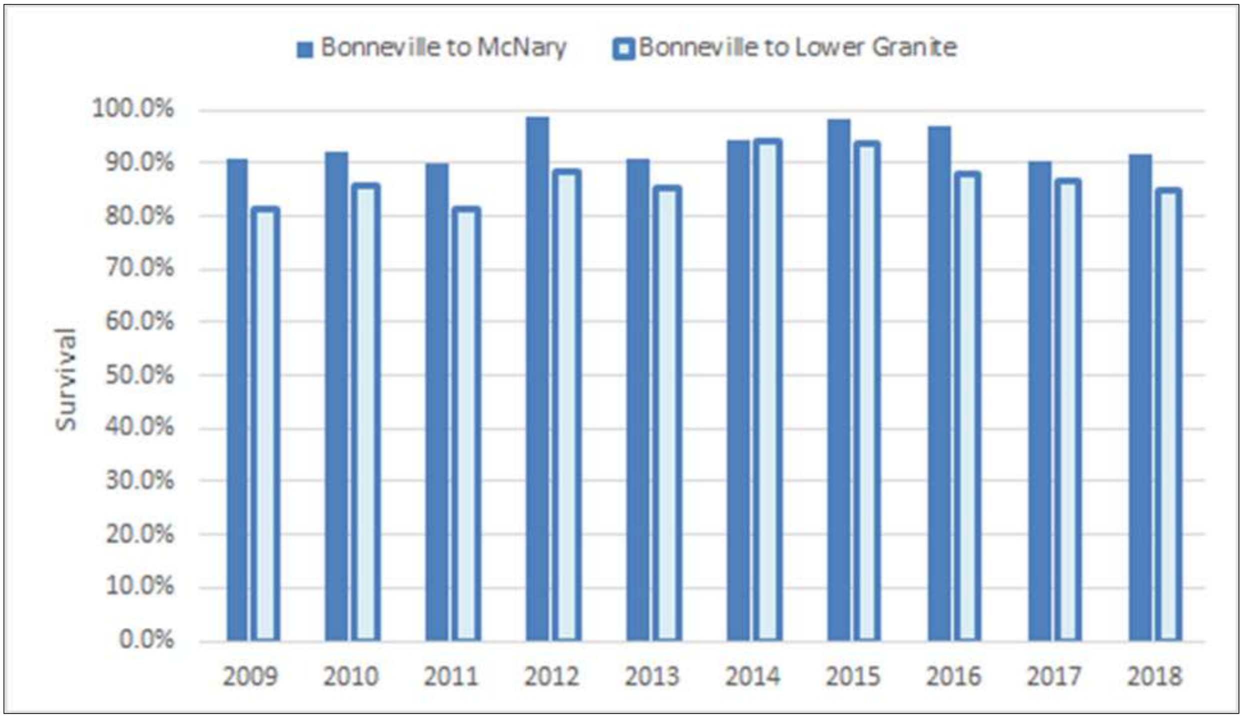

Figure 2.3-5. Minimum survival estimates (corrected for harvest and straying) from Bonneville to McNary and Bonneville to Lower Granite Dams (2009 to 2018) estimated using known-origin PIT-tagged adult SRB steelhead—natural- and hatchery-origin combined—that migrated inriver as juveniles. Source: NMFS, using data from PITAGIS.

Some SRB steelhead are incidentally killed during turbine maintenance and testing activities associated with the operation of Dworshak Dam. In November of 2016, approximately 200 adult SRB steelhead mortalities were observed after an extended commission and testing operation of unit two. The majority of these fish were estimated to be of hatchery origin from the Clearwater River MPG and did not impact broodstock collection. In testing this unit, an unusually high number of starts and stops and long durations of speed no load operations[96] were used and likely contributed to the mortality event. Efforts to reduce mortality associated with turbine maintenance are occurring with changes in the annual Fish Passage Plan. Maintenance operations and improvements in protocol have resulted in less than 10 mortalities observed from 2017 through 2019.

During July and August, solar radiation heats reservoir surface waters, which can lead to high temperatures and temperature differentials between the bottom and top sections in a fish ladder. Ladder temperatures exceeding 68°F and differentials greater than 1.8°F have been demonstrated to delay passage for steelhead and Chinook salmon at the CRS dams in the Lower Snake River (Caudill et al. 2013). As temperature differentials increase, time required for passage increases; a temperature differential of 5.4°F increased the ladder passage time for summer Chinook at Lower Granite Dam by a factor of 2.0 to 2.2 compared to no temperature differential. Caudill et

[96] Speed-no-load operations are temporary operations that occur when turbines are spinning but not used to generate power, for example during testing.

al. (2013) noted that the increased travel time, increased thermal exposure, and related physiological stresses could reduce successful migration to natal tributaries. Ladder temperatures commonly exceed 68°F, and ladder differentials regularly exceed 1.8°F (McCann 2018). During the most extreme summer days, ladder temperatures in CRS dams can exceed 75.0°F, and ladder differentials can exceed 4.5°F (FPC 2019). Fish ladder–cooling structures have been installed at Little Goose and Lower Granite Dams that pump colder water from deeper in the reservoir into the fish ladder to reduce ladder temperature differentials. There are currently no structures to reduce ladder temperatures at the other CRS dams, but research has identified that during the warmest months, cooler water is available that could be pumped into ladder exits to reduce high temperatures and ladder differentials (Lundell 2019).

During trapping operations for SR sockeye salmon at Lower Granite Dam, SRB steelhead are incidentally handled. From 2013 to 2017, an average of 6,038 steelhead were handled annually. Injuries and mortalities of SRB steelhead associated with this trapping are low (Ogden 2018).

CRS-related mortality of downstream migrating kelts is not well known at this time.[97] Colotelo et al. (2013) estimated that in 2012, only 40.2 and 44.8 percent of SRB steelhead kelts survived from the Lower Granite forebay to the Lower Columbia River (RM 156) and the Bonneville dam face (RM 234), respectively, and only 60.4 and 67.3 percent survived from the McNary forebay to the lower Columbia River (RM 156) and Bonneville dam face (RM 234), respectively. It is important to note that tagging occurred after spring spill had begun, and only fair and good condition kelts were selected for tagging in this study, so these survival rates cannot be applied to poor condition kelts. In another acoustic tagging study conducted by Harnish et al. (2014) (using the same fish condition requirements), the survival of steelhead kelts through the four Snake River dams averaged 77 percent in 2012 and 49 percent in 2013. Based on this limited information, up to 60 percent of migrating SR kelts are lost passing all eight Snake River and lower Columbia River dams (less for the Tucannon River population) and up to 50 percent arriving at Lower Granite dam are lost before reaching the Ice Harbor dam tailrace.

These data represent total mortality to outmigrating kelts and do not distinguish between mortality caused by effects of CRS operations and other factors. Estimates of "natural" mortality rates for these fish are not available but are thought to be high, since they have typically gone many months without feeding while expending considerable energy migrating and spawning.

2.3.2.1.6 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and non-native species that are predators, competitors, or food sources for migrating juvenile steelhead. Travel times of migrating smolts increase as they pass through the reservoirs (compared to a free-flowing river),

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[97] A kelt is an adult steelhead that has spawned successfully and is returning to the ocean, with the chance to return upstream to spawn again, unlike most other anadromous fish.

increasing exposure to both native and nonnative predators (see Predation section below), and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spillbays, or surface passage routes) (NMFS 2008a).

However, based on data summarized in Zabel (2019) and Widener et al. (2020), overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1998, when the species was listed. This improved survival rate correlates with improved structures, operations, and predator-management programs at the Corps' mainstem projects (24-hour volitional spill, surface passage routes, improved juvenile bypass systems, predator-management measures, etc.) (NMFS 2017a).

Table 2.3-7 depicts the FOP for spring spill in 2017 through 2020. There was a substantial increase in spill over the dam spillways in the spring of 2018 in response to a court order requiring additional spill. Spill levels in 2019 and 2020, using flexible spill as defined in the proposed action subject to consultation in the 2019 CRS biological opinion, were also higher than previous prescribed spill levels. Spill in 2018, as a percentage of flow at Snake River dams, averaged 37.2 percent, with daily mean spill percentages above the long-term spill average (1993 to 2018) for nearly the entire migration period. In the spring of 2019, during the 120 percent flexible spring spill operation, mean discharge in the Snake River was high at 45.5 kcfs, which was above the 2006 to 2019 mean of 34.3 kcfs. In 2019, spill averaged 38.5 percent at the Snake River dams, which was above the long-term mean of 34.6 percent, but lower than what would be expected with flexible spill during low and moderate flow years.

Table 2.3-7. Summary of 2017, 2018, and 2019, and 2020 Fish Operations Plan spring spill levels at lower Snake River and Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flexible Spill	2020 Flexible Spill
Lower Granite	20 kcfs/20 kcfs	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 20 kcfs Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 20 kcfs Performance Standard (8 hours per day)
Little Goose	30%/30%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)
Lower Monumental	Gas Cap/Gas Cap (approximate Gas Cap range: 20–29 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (uniform spill pattern, 16 hours per day) / 30 kcfs Performance Standard (bulk spill pattern, 8 hours per day)	125% TDG gas cap (uniform spill pattern, 16 hours per day) / 30 kcfs Performance Standard (bulk spill pattern, 8 hours per day)
Ice Harbor	**April 3-April 28:** 45 kcfs/Gas Cap	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 30% Performance Standard (8	125% TDG gas cap (16 hours per day) / 30% Performance Standard (8

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flexible Spill	2020 Flexible Spill
	April 28-June 20: 30%/30% vs. 45 kcfs/Gas Cap (approximate Gas Cap range: 75–95 kcfs)		hours per day)	hours per day
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)
John Day	**April 10–April 28:** 30%/30% **April 28–June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 40% Performance Standard (8 hours per day)	40%/40%
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)	120% TDG gas cap (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)	125% TDG gas cap up to 150 kcfs (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)

[1] Spill operations are described as percent of project outflow or kcfs.

Widener et al. (2018, 2020) estimated juvenile SRB steelhead survival rates (natural-origin and hatchery combined) from Lower Granite Dam to McNary Dam (four reservoirs and dams), and from Lower Granite Dam to Bonneville Dam (seven reservoirs and dams). They found that in 2008 to 2017, survival rates averaged 71.7 percent (Lower Granite to McNary Dam, ranging from 62.8 to 79.0 percent) and 55.5 percent (Lower Granite to Bonneville Dam, ranging from 41.6 to 75.7 percent; Figure 2.3-6). These survival rates incorporate multiple sources of mortality such as dam passage mortality, natural mortality, and predation. The estimated Lower Granite to Bonneville Dam survival estimate for 2018 (under the court-ordered spill operation) was 58.8 percent, which is above the long-term average of 47.0 percent. During the 120 percent flexible spill operation in spring of 2019, the estimated Lower Granite to Bonneville Dam survival was 42.7 percent, which is below average for SRB steelhead (Zabel 2019, Widener et al. 2020). The reduced survival rates in the lower Columbia River (difference of Lower Granite to McNary Dam and Lower Granite to Bonneville Dam) starting in 2015 were likely influenced by increased predation by Caspian terns displaced from Crescent Island to the Blalock Islands in John Day Reservoir (Roby et al. 2016).

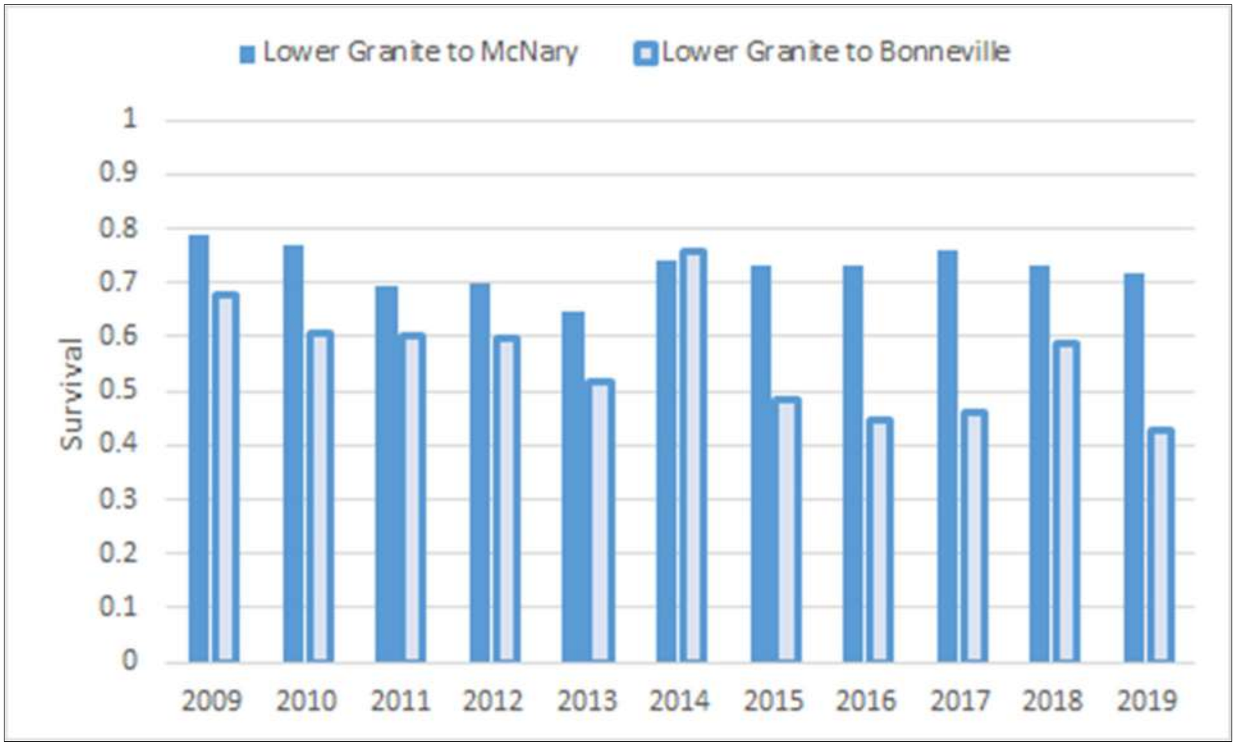

Figure 2.3-6. Survival estimates of SRB steelhead smolts (natural-origin and hatchery combined) from Lower Granite to McNary and Lower Granite to Bonneville Dams (2008 to 2019). Source: Widener et al. 2019.

Estimates of steelhead smolt (hatchery and natural-origin combined) survival in 2018 (Zabel 2019, Widener et al. 2020), resulting from court-ordered "gas cap" spill operations, were 73.3 percent from Lower Granite to McNary Dams and 58.8 percent from Lower Granite to Bonneville Dams. Survival estimates in 2018 and 2019 are within the range of survival estimates in these reaches observed between 2008 and 2017.

Together, these survival rates, which include effects of hydrosystem operations, represent a substantial improvement in migration conditions and survival rates for juvenile SRB steelhead migrating through the impounded reaches of the lower Snake and lower Columbia Rivers compared to the 1980s and 1990s (NMFS 2008a), which has the potential to increase the overall productivity of the populations and the abundance of returning adults.

2.3.2.1.7 Transportation

Juvenile fish transport has been used for mitigation in the CRS since 1981 (Baxter et al. 1996). The goal of transportation is to avoid mortality directly caused by migration past dams and thus to increase the number of fish that return as adults. Turbine intake screens, part of the juvenile bypass systems, divert smolts away from turbine units and into a system of channels and flumes before bypassing them into the tailrace below the dam or collecting them in raceways where they can be loaded onto barges or trucks, transported below Bonneville Dam, and then released into the lower Columbia River to continue migrating to the ocean. Dams currently used for collection are Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam. SRB steelhead smolts were transported from McNary Dam from 1985 to 2011, no steelhead were transported in 2012 transport operations at McNary, and after 2012 all transport from McNary Dam ceased based on a recommendation from NMFS.

The effectiveness of the transportation program is evaluated annually. After the initiation of transportation, nearly all collected fish from the run-at-large are transported. However, the detection and collection system allows for a portion of PIT-tagged fish to continue to be bypassed. This allows assessment of transportation by comparing survival rates of transported and bypassed fish.

The primary metrics for assessing transport apply ratios of smolt-to-adult return (SAR) rates for transported fish relative to SARs for fish that remained inriver and passed through the hydrosystem by other routes during migration. Several types of ratios are useful, differing by which inriver fish are included in the ratio. This document uses two types of transport ratio to describe effects of transport on adult returns. These ratios are described below:

1. Transport-In-River Ratio (TIR): The TIR is the ratio of the SAR of fish transported from Lower Granite, Little Goose, or Lower Monumental Dams, relative to the SAR of fish that never entered a collection system at these dams. PIT-tagged fish used for TIR estimates come only from fish tagged upstream of Lower Granite Dam, and smolt number estimates are adjusted to account for mortality between Lower Granite Dam and the downstream transport site. The Comparative Survival Study (CSS) uses this metric to report transport results.
2. Transport-Bypass Ratio (T:B): The T:B is the ratio of the SAR of fish transported from a specific collector project, relative to the SAR of fish that entered the same collection system and were then bypassed to the river downstream. The NWFSC generally uses this metric to report transport results.

Both of these ratios are used to describe adult return rates to Lower Granite Dam and sometimes to other projects (e.g., Bonneville Dam).T:B and TIR greater than one indicate that transported fish returned as adults to Lower Granite Dam at higher rates than corresponding bypassed or inriver fish. T:B and TIR less than one indicate that transported fish returned as adults at lower rates than corresponding bypassed or inriver fish. Because the two ratios compare effects of transportation to effects of different passage routes, they can address different management questions. The T:B provides direct evidence regarding the alternative management options for fish that enter the juvenile bypass system at a collector dam. A T:B greater than one indicates that, among the subset of fish that entered the powerhouse and were diverted into the bypass system, transported fish had higher SARs than bypassed fish. The TIR provides a different perspective, by comparing SARs for transported fish to those for fish that never entered a bypass system at a Snake River collector project. These inriver fish passed all collector dams via spillways or turbines. A TIR less than one suggests that management options should focus on decreasing the total number of fish entering the powerhouse.

Estimates from PIT-tagged fish have shown that fish that are bypassed at one or more collector dams generally have lower SARs than inriver fish that pass without ever encountering a bypass system. The majority of these never-detected fish pass dams via spillways, with a minority passing via turbines. For SRB steelhead, T:B estimates tend to exceed TIR estimates. In this sense, TIR represents a higher standard by which to assess the efficacy of transportation. Both measures have merits and are best viewed collectively. An advantage of T:B is that data on transport effects can be evaluated on a finer temporal scale than is possible with TIR. Each PIT-tagged fish that enters the bypass system is detected. Thus, the date on which the fish was transported or bypassed is known, and date-specific T:Bs can be estimated. Fish that pass through spillway or turbine routes are not detected, and thus have an unknown passage date, which means that TIR can be estimated only on an annual scale.[98]

Juvenile steelhead begin arriving at the three collector dams in early April. Since 2006, fisheries managers have chosen not to transport fish in the run-at-large for the first three or four weeks of April; fish that enter the juvenile bypass system are exclusively bypassed during this early period. This choice was based on temporal T:B data from prior years that showed no benefit for fish transported early in the season. The same data set showed that later in the season, starting in late April or early May, transportation resulted in higher SARs than bypassing. Thus, since 2006 managers generally have chosen to initiate transportation around May 1st. For the years 2018 and 2019, the fishery managers chose to start transport on April 24. The earlier date was selected because in recent years juveniles had begun migrating earlier and the majority of the run would often pass the projects before transport was started on May 1.[99] The earlier start date also allows an evaluation of transport during the last week of April, which will provide managers information to assess transport decisions in this timeframe.

Annual T:B estimates are derived from data collected only during the “transportation period;” fish that were bypassed in April before transportation are excluded from the calculation. Because the inriver fish used in calculating TIR do not acquire a “date stamp” when they pass the collector dams, the annual TIR estimates include the fish that were bypassed during the early period, when there were no corresponding transported fish.

In recent smolt migration years (2007 to 2019), the average percentage transported was 42.5 percent (range 18.7 to 63.3) for natural-origin and 33.1 percent (range 13.2 to 46.9) for hatchery SRB steelhead. These estimates represent a substantial reduction from the period from 1993 to 2006, when proportions transported averaged 86.7 percent for natural-origin and percent for 86.0 percent for hatchery SRB steelhead (Widener et al. 2020). The reduction in recent years was due to both increased spill levels and a later transport start date (typically around May 1) at the three Snake River collector projects. Transport rates for SRB steelhead smolts in 2018 and 2019 were

[98] A PIT-tag detection system has been installed in one spillbay at Lower Granite Dam, and will be used for the first time in smolt migration year 2020. This will be the first time that a passage route other than a juvenile bypass system has been monitored.

[99] On average (2010-2019) for SRB steelhead, the proportion of the total annual smolt outmigration that had arrived at Lower Granite Dam was 10 percent on April 15, and 50 percent on May 2 (DART 2020j).

higher than average for most recent years due to relatively early start dates (April 23 in 2018 and April 24 in 2019). In 2018, 63.3 percent of natural-origin and 44.5 percent of hatchery smolts were transported. In 2019, 44.1 percent of natural-origin and 35.5 percent of hatchery smolts were transported (Widener et al. 2020). Run timing was particularly early in 2019. In 2019, 50 percent of steelhead smolts reached Lower Granite Dam by April 23, representing the earliest date of median passage on record (since 1995) (DART 2020j). If transport had not started until May 1 (collection starting on April 29) in 2019, 75 percent of the juvenile run would have already passed Lower Granite Dam. This illustrates that a relatively small difference in transport start date can have a large influence on the proportion of fish transported

In most cases, for hatchery and natural-origin SRB steelhead from smolt migration years 2006-2017, SARs were higher for transported fish than for bypassed or inriver fish (i.e., the T:B or TIR were greater than 1.0, Table 2.3-8). The year 2006 was chosen as the earliest year for this analysis, because 2006 was the first year that spill was provided on a 24-hour basis at all Snake River projects, and also the first year that transportation began mid-season, and these strategies are likely to continue in some form into the future.

Table 2.3-8. Analysis of effects of transport on adult return rates for hatchery (aggregate) and natural-origin Snake River Basin steelhead using the NWFSC metric, T:B (Smith et al. 2018) and the CSS metric, TIR (CSS 2019).

	T:B		**TIR**	
Year	**Hatchery Steelhead**	**Natural-origin Steelhead**	**Hatchery Steelhead[1]**	**Natural-origin Steelhead**
2006	1.73	1.68	1.50	0.97
2007	2.77	2.47	1.66	2.93
2008	1.46	1.22	1.24	1.18
2009	1.40	2.00	1.07	1.33
2010	1.21	1.40	0.90	1.46
2011	1.57	1.81	1.15	1.21
2012	1.48	2.30	0.83	0.91
2013	1.43	1.90	1.44	2.18
2014	1.94	2.66	1.22	2.23
2015	19.83	0.78	1.57	1.10
2016[2]	1.46	2.31	1.17	1.57
2017[2]	1.89	4.92	NA	NA
Geometric mean	2.00	1.93	1.22	1.45

NOTE: The NWFSC T:B estimates represent a comparison of SARs for fish tagged above Lower Granite and either transported (T) or bypassed (B) at Lower Granite. The CSS TIR estimates come from the 2019 CSS Annual Report, and represent the T_0 or T_x SAR, relative to fish never detected at a collector project (C_0 SAR).

[1]TIR is reported for Snake River hatchery programs (aggregate) and the estimated TIR for natural-origin fish

[2]Incomplete adult returns at time of analysis.

The efficacy of smolt transportation as a mitigation measure varies by species, rearing type, and collector dam. Transportation has generally benefited hatchery and natural-origin SRB steelhead. Results for fish transported from Little Goose Dam are generally similar to those transported from Lower Granite Dam. However, transportation is generally less beneficial from Lower Monumental Dam, where fewer fish are transported than from the dams farther upstream.

While the overall result is positive, smolt transportation is not a panacea (Williams et al. 2005). Informally, a regional goal is for survival of inriver migrants to meet or exceed that observed for transported fish. That goal has not yet been met for spring migrants, but survival rates for transported fish provide an important benchmark. The alternative to transportation is to improve inriver migration conditions to the point where transportation provides little benefit. Over the last several decades various transportation strategies have been proposed and have been reviewed by the ISAB, most recently in 2010 (ISAB 2010). The guidance provided by the ISAB has been consistent, which is to "spread the risk" between transport and inriver passage, and to measure the effects of inriver survival and transportation over time. The T:B and TIR ratios provide the information necessary to measure these effects.

Since 2006, efforts to improve conditions for smolts migrating inriver have included the provision of 24-hour spill during juvenile migration at all of the mainstem projects, the addition of surface passage structures, and the relocation of juvenile bypass outfall locations to improve inriver survival of bypassed fish. The most recent change was the implementation of the Flexible Spill Agreement, which as of spring 2020 had increased spring spill levels up to a 125 percent TDG tailrace standard (16 hours per day) at the Snake River projects and McNary Dam (NMFS 2019a).

While higher spill is anticipated to result in fewer smolts at a project being bypassed and collected for transport, that effect would not be uniform under all flow conditions. At a given spill level, more fish will pass via spill under low-flow conditions. In low-flow year 2015, only 16.0 percent of steelhead smolts that arrived at Lower Granite Dam were ultimately transported from one of the collector dams (Zabel 2019). Migration year 2015 had slightly below-average inriver survival (48.6 percent smolt survival between Lower Granite and Bonneville Dams), and transport provided an above-average survival benefit for hatchery steelhead (T:B of 19.8 from Lower Granite Dam), though not for natural-origin steelhead (T:B of 0.78 from Lower Granite Dam). Thus, when inriver conditions are poor due to low flows and high water temperatures, as in 2015, in-season management decisions must weigh the potentially large benefits of increasing the proportion of fish transported against the general desire to improve inriver conditions, with spill as the main strategy identified to date.

In general, determining an "optimum" transport operation is challenging for several reasons. The benefit of transportation varies seasonally, by river flow and temperature conditions, by collector dam, and likely also because of differing ocean conditions at the time of ocean entry for transported and inriver migrants. Seasonal patterns in the SARS of transported and inriver migrants also vary by species and rearing type. Broadly speaking, juvenile transport continues to show an overall benefit for SRB steelhead, in the form of rates of survival to adulthood that exceed those for fish that are not transported. However, the degree of benefit has decreased since 2006, when management modifications (increased spill and initiation of smolt collection later in the migration season) were implemented for juvenile SRB steelhead. Subsequently, inriver survival has increased and the proportion of smolts being transported has decreased.

In addition, transport has unintended consequences. Handling and transport of juveniles results in their being held at much higher densities than observed in the wild, increasing the risk of disease transmission. Also, because it takes inriver migrating fish several weeks to travel from the lower Snake River to Bonneville Dam, and they are growing during that period, inriver migrants are larger and enter the Columbia River estuary and plume later in time than transported fish. Smaller size at ocean entry is associated with reduced survival (NMFS 2014a). These factors, in some combination, likely contribute to the sometimes observed higher mortality for transported fish after being released from barges compared to inriver migrating smolts as evidenced by adult returns to Bonneville Dam (NMFS 2008a).

Another unintended consequence of transportation is increased straying of returning adults (Keefer and Caudill 2014). Smolts that migrate inriver take 2 weeks or longer to travel from Lower Granite Dam to Bonneville Dam, imprinting on the varying water chemistry of tributaries as they go. Smolts transported in barges follow the course of the river, but they make the trip in 2 to 3 days. It appears that the reduced transit time prevents fish in barges from acquiring waypoints along the migration route as effectively, and this can result in less directed upstream migration for returning adults. Returning fish that were transported as smolts are more likely to wander into tributaries, either temporarily or permanently, or to fall back after passing dams. This increases travel time and likely results in increased exposure to warm water temperature in the late summer and increased exposure to lower Columbia River fisheries. Keefer et al. (2008) studied the effects of barged and inriver migrating steelhead during the juvenile migration years 1998 to 2003. They found that adult steelhead that had been transported as smolts had lower homing behavior, higher unaccounted-for losses, and higher straying rates than inriver migrants. The transport effect on straying was significant for natural-origin steelhead but not for hatchery fish. Marsh et al. (2015) found that for SRB steelhead transported as juveniles in 2006 to 2008, 6.7 to 9.5 percent strayed as adults during their upstream migration, with 5 to 7 percent of the adult migrants permanently lost (i.e., never detected at Lower Granite Dam as adults).

The SARs presented in this document are based on adults counted at Lower Granite Dam. Thus, losses of transported fish resulting from straying are accounted for, and TIR and T:B estimates still show a general benefit of transport. Uncertainty remains about whether alteration of adult-homing behavior has important consequences for fitness after adults successfully pass Lower Granite Dam. In addition, Snake River fish that permanently stray into and spawn in non-natal streams can have an adverse effect on the native population of those streams (Keefer et al. 2008, Keefer and Caudill 2014).

Concern about non-native steelhead breeding with non-target populations in the John Day River was noted by Ruzycki and Carmichael (2010). However, they found that the proportion of hatchery-origin spawners appears to have declined over time, from 31 percent in 2004 down to only 6 percent in 2009. This decline coincided with a decline in the number of steelhead smolts transported from Snake River dams. Before 2006, 90 percent or more of SRB steelhead smolts were transported; the average for 2006 to 2015 was only 40 percent.

2.3.2.2 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Currently, there are 13 steelhead hatchery programs in the Snake River basin, plus one kelt reconditioning program. Six of the hatchery programs are considered to be part of the DPS: the Tucannon River, Dworshak National Fish Hatchery, Lolo Creek, North Fork Clearwater, East Fork Salmon River, and the Little Sheep Creek/Imnaha River Hatchery steelhead hatchery programs (see Section 2.3.1.1.1).

The kelt reconditioning program consists of the collection of post-spawned steelhead greater than 60 centimeters and the administration of disease-preventative medications and feed for the purpose of improving survival over what would be expected without intervention (since typically kelts are in fairly poor condition after spawning and may have low chances of surviving downstream migration. Upon release, these fish are intended to return to natal populations, thereby increasing spawner escapement and productivity if reconditioned individuals successfully spawn (NMFS 2017f).

Evidence indicates that several B-Index steelhead populations targeted by the kelt reconditioning program have likely benefited from this program. Since 2008, the Snake River kelt reconditioning program has been operating at a research scale, and while the facility has been reported to be too small to reach the program’s goal of increasing the Lower Granite Reservoir ladder count of B-Index steelhead by 6 percent (Hatch et al. 2018), the program has demonstrated the feasibility of reaching the goal. In 2013, 69 reconditioned B-Index steelhead were released (approximately 40 percent of the program’s goal). In 2015, 24 reconditioned B-Index steelhead were released below Lower Granite Dam, and an additional 21 fish were determined to be skip spawners and retained for release in 2016. Twenty-two fish were released in 2016, and 98 fish were released in 2017. The 2017 release of 98 premature fish was composed of 77 skip spawners, with fecundities approximately 1.51 times those of maiden fish, and 21 consecutive spawners, with fecundities approximately 1.27 times those of maiden fish (Hatch et al. 2018). BPA funds the Snake River Kelt Reconditioning Program as mitigation for the CRS, but it is not a steelhead production program.

Hatchery programs for some SRB steelhead populations serve the dual purpose of providing fish for fisheries and providing supplemental spawners to help rebuild depressed natural populations.

Most hatchery production for SRB steelhead was initiated under the Lower Snake River Compensation Plan (LSRCP) as part of the Water Resources Development Act of 1976 (90 Stat. 2917). The LSRCP included a program to design and construct fish hatcheries to compensate for some of the losses of salmon and steelhead adult returns incurred as a result of the construction and operation of the four lower Snake River hydroelectric dams. Mitigation goals for the LSRCP program include 55,100 adult steelhead. The program is administered by the USFWS. Production under the LSRCP began in the mid-1980s.

The Dworshak Dam mitigation program provides hatchery production of steelhead as compensation for the loss of access to the North Fork Clearwater River (NMFS 2017f). Dworshak National Fish Hatchery, completed in 1969, is the focus for that production. Hatchery fish are also produced as mitigation for fish losses caused by construction of the Hells Canyon Complex in the Snake River Hells Canyon area. None of the Hells Canyon Complex dams, which are owned and operated by the Idaho Power Company, have fish passage facilities. The Idaho Power Company built four hatcheries to mitigate the Hells Canyon Complex's effects on native fish populations: Oxbow, Rapid River, Niagara Springs, and Pahsimeroi Hatcheries. The four hatchery facilities are managed by the IDFG.

Hatchery practices for SRB steelhead have evolved as the status of natural populations has changed, and new plans are being implemented and evaluated as a result of recent ESA consultations on HGMPs for every steelhead hatchery program in the Snake River basin. These consultations concluded that hatchery programs in the Snake River basin are not likely to appreciably reduce the likelihood of survival and recovery of the Snake River Steelhead DPS (NMFS 2017f, 2017g). The consultations also included terms and conditions for continued monitoring of the hatchery programs and their effects on listed species.

Several uncertainties exist regarding the effects of hatchery programs on natural-origin SRB steelhead populations. One of the main areas of uncertainty is the relative proportion and distribution of hatchery-origin spawners in natural spawning areas at the population level, particularly for SRB steelhead (NWFSC 2015). Because of this lack of information, the status of most of the populations in the DPS remains highly uncertain. Information is needed to determine where, and to what extent, unaccounted for hatchery steelhead are interacting with ESA-listed populations, particularly in Idaho (NWFSC 2015). Co-managers have continued to install PIT tag arrays throughout the Snake River basin that are likely to provide new information on population abundance and productivity as well as hatchery fish proportions and distribution throughout the Snake River basin. In addition, NMFS, hatchery funding agencies, and the state and tribal co-managers participate in a Snake River Steelhead Workgroup to continue to collaborate on these uncertainties.

2.3.2.3 Recent Ocean and Lower River Harvest

The largest harvest-related effects on SRB steelhead result from the implementation of tribal and nontribal mainstem Columbia River fisheries (NMFS 2017a). These fisheries target harvestable hatchery stocks migrating through commercial fishing zones 1 to 6 in the lower portion of the mainstem Columbia River, extending from the river mouth to McNary Dam. Mortality associated with tributary fisheries also occurs in some areas. Mortality associated with ocean fisheries, which target fall-run Chinook and coho salmon, is rare for steelhead (NMFS 2017a). This is because the migration path and ocean distribution of SRB steelhead is such that they are not present in nearshore areas where ocean salmon fisheries traditionally occur (NMFS 2014b). Non-treaty commercial harvest of steelhead has been prohibited since 1975. Before efforts during the last few years to promote commercial selective fisheries, fishery managers used time, area, and gear restrictions to limit handling and mortality of steelhead by the non-treaty fishery to less than 2 percent of the run (NMFS 2018a). In addition, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986. Of the fish that are caught and released, it is assumed that 10 percent will die from handling-related injuries. This release mortality rate is the *U.S. v. Oregon* Technical Advisory Committee's scientific recommendation, which is updated whenever new information becomes available through a combination of reviewing current scientific literature and incorporating Columbia River basin–specific studies examining natural-origin steelhead captured and released from recreational gear used during spring, as seasonal temperature changes are known to affect release mortality rates differently (TAC 2017). Incidental mortality refers to mortality of fish that are harvested but are not the target species or stock; these are caught and released, or captured by fishing gear but not landed.

Fisheries in the Columbia River basin, particularly in the mainstem of the Columbia River, are managed pursuant to fishing plans developed by the parties to the *U.S. v. Oregon* Management Agreement. Parties to this process include the Federal government; the states of Oregon, Washington, and Idaho; the four Columbia River Treaty Tribes; and the Shoshone-Bannock Tribes. The majority of incidental mortality on natural-origin SRB steelhead occurs in Columbia River mainstem tribal gillnet and dip net fisheries that target hatchery steelhead, coho, and fall Chinook salmon. The B-Index component of the summer steelhead run, which returns to spawn in Idaho's Salmon and Clearwater River drainages, is thought to be more vulnerable to harvest in gillnet fisheries and experiences higher fishing mortality than the A-Index component. B-Index steelhead also have a run timing distribution similar to fall-run Chinook salmon, and are susceptible to harvest in tribal fisheries directed at these fish (Copeland et al. 2017). Harvest mortality has been reduced substantially in response to evolving conservation concerns.

Steelhead impacts associated with fall season treaty fisheries were managed from 1986 to 1998 pursuant to the guidelines contained in the now expired Columbia River Fisheries Management Plan (CRFMP). That plan allowed for a 32 percent tribal harvest rate on B-Index steelhead during the fall season. The allowable fishing rate was reduced in hopes of providing necessary protections to B-Index steelhead. The average B-Index harvest rate from 1985 to 1997 was 26.0 percent. Then in 1998, to address ESA constraints, harvest for B-Index steelhead was reduced further to a 15 percent harvest rate cap, and the harvest rate from 1998 to 2008 in the tribal fall season fishery averaged 11.5 percent. The 15 percent harvest rate cap represented a 42 percent reduction from the long-term average harvest rate for the tribal fishery, and a 53 percent reduction from the CRFMP allowed harvest rate of 32 percent (NMFS 2018a). In 2008, a tiered structure for fall harvest rates was introduced: 13 percent for run sizes less than 20,000, 15 percent for run sizes between 20,000 and 35,000, and 20 percent for run sizes above 35,000. These caps included both clipped and unclipped steelhead. Since then, the average harvest rates (including tribal and recreational fisheries) have been 6.5 percent on unclipped A-Index steelhead and 17.9 percent on unclipped B-Index steelhead (TAC 2017, Table 3.3.52).

Summer fisheries since 2008 have averaged 1.5 percent on unclipped A-Index steelhead and 2.4 percent on unclipped B-Index steelhead, and the treaty winter/spring harvest rates on unclipped A-Index steelhead and unclipped B-Index steelhead during winter/spring fisheries have averaged 0.1 and 0 percent, respectively (TAC 2017). For all fishing seasons combined, the average annual treaty harvest rate from 2008 to 2018 on the unclipped portion of the B-Index steelhead stock was 14.8 percent (JCRMS 2019).

For management purposes, the steelhead run year starts on July 1 at Bonneville Dam. From July 1 to July 31, a separate 2 percent harvest rate limit begins on natural-origin A- and B-Index steelhead in fisheries upstream from the mouth of the Columbia River. A portion of the annual steelhead run is unclipped hatchery-origin fish, and this component is annually calculated to correct for the actual natural-origin steelhead return (TAC 2017). Beginning August 1, a new 2 percent harvest rate limit on the natural-origin component of each index applies to fisheries that affect the same set of returning fish that occur through October 31. This fall harvest rate limit extends from November 1 through December 31 for fisheries upstream of The Dalles Dam.

For fisheries upstream of The Dalles Dam to the Washington/Idaho border, January through June 30 (the winter/spring management period) fisheries are limited as part of the same 2 percent harvest rate limit that occurred in July, since these are the same run of steelhead that have now migrated upstream in the Columbia River basin. In total, each index is subject to a maximum 4 percent harvest-rate limit on natural-origin steelhead each run year (NMFS 2018a). Generally, the status of B-Index steelhead is worse than that of A-Index steelhead. B-Index steelhead are subject to higher harvest rates because they are the limiting stock, generally in lower abundance and, therefore, caught at levels closer to their annual limit.

In terms of catch, thousands more A-Index fish are caught; however, the harvest rate of the entire A-Index is lower because there are so many more fish classified as A-Index fish in the river. Consequently, there are no specific management constraints in tribal fisheries for A-Index steelhead because the constraints for B-Index fish are restrictive enough to also provide surrogate protection for A-Index steelhead (NMFS 2018a).

Treaty-tribal fall season fisheries are currently managed using the abundance-based harvest-rate schedule for B-Index steelhead, as contained in the 2018 *U.S. v. Oregon* Management Agreement. Under the abundance-based harvest rate schedule, the harvest rate limit may change depending on the abundance of B-Index steelhead. The harvest rate allowed under the current harvest rate schedule is also limited by the abundance of upriver fall Chinook salmon. The purpose of this provision is to recognize that impacts to B-Index steelhead may be higher when the abundance, and thus fishing opportunity for fall Chinook salmon, is higher and remains consistent with conservation goals. However, higher harvest rates are allowed only if the abundance of B-Index steelhead is also greater than 35,000. This provision is designed to provide greater opportunity for the tribes to satisfy their treaty right to harvest 50 percent of the harvestable surplus of fall Chinook salmon in years when conditions are generally favorable. Even with these provisions, it is unlikely that the treaty right for Chinook salmon or steelhead can be fully satisfied. The harvest rate in tribal fall season fisheries may range from 13 to 20 percent, and the non-treaty fall season fishery harvest rate would remain fixed at 2 percent. B-Index steelhead are used as the primary steelhead-related harvest constraint for tribal fall season fisheries, and are the indicator stock used for management purposes. Several tribes also have treaty rights to fish for steelhead in the Snake River basin. As a consequence, co-managers in the Snake River developed fishery frameworks that allow for the allocation of available fishery impacts based on the total number of fish annually escaping saltwater and freshwater fisheries downstream before their return to the upper Snake River basin.

Based on discussions during 2018 and 2019 with fishery managers in the Snake River basin (ODFW, WDFW, IDFG, Shoshone-Bannock Tribes, Nez Perce Tribe, and the Confederated Tribes of the Umatilla Reservation), NMFS completed a biological opinion on the effects of fisheries targeting steelhead in the Snake River basin. The current framework sets a natural-origin impact rate for each MPG in the SRB steelhead DPS, as well as low abundance thresholds for each MPG to curtail fisheries when steelhead abundances fall below these thresholds. Our analysis in the recently completed biological opinion (NMFS 2019c), found that the action did not result in jeopardy or adverse modification of critical habitat for any of the four affected ESA-listed species.

2.3.2.4 Tributary Habitat

2.3.2.4.1 DPS Overview

Tributary habitat conditions for steelhead vary significantly throughout the Snake River basin: in some areas, spawning and rearing habitat is in near-pristine condition, while in others it is minimally to highly degraded as a result of past or present human activities. Generally, the ability of tributary habitats in the Snake River basin to support the viability of this DPS is limited by one or more of the following factors: 1) impaired fish passage, 2) reduced stream complexity and channel structure, 3) excess fine sediment, 4) elevated summer water temperature, 5) diminished stream flow during critical periods, 6) reduced floodplain connectivity and function, and, 7) degraded riparian condition. The combination, intensity, and relative impact of these factors vary locally throughout the basin, depending on historical and current land use activities and natural conditions.

Human activities that have contributed to these limiting factors include past and/or current grazing, mining, logging, agricultural practices, road construction, water withdrawals, urban development, and recreational use (NMFS 2017a). Natural disturbances, particularly fire, have also had an impact recently in several subbasins. Fires are natural disturbances that, from an ecological perspective, allow over time for the development and maintenance of the complex habitats needed by salmonids. However, in the near term, they are also likely to result in higher runoff rates and erosion leading to increased sediment load and streambed scouring, with associated adverse effects on salmon productivity (Bixby et al. 2015, Flitcroft et al. 2016). Changes in precipitation and temperature also have influenced, or are likely to influence, trends in habitat conditions. Changes are predicted to include more precipitation falling as rain rather than snow; diminished snowpack and altered stream flow, volume, and timing; lower late summer flows; higher summer and fall water temperatures; and increased impacts of drought due to more dry and warm years (NMFS 2017a).

In general, land use practices and regulatory mechanisms have improved from historical practices and regulations (NMFS 2017a). Roper et al. (2019), for instance, reviewed the status and trends of 10 stream habitat attributes to evaluate whether changes in Federal land management had altered the trajectory of stream habitat conditions in the interior Columbia River basin. They concluded that changes in management standards and guidelines made in the 1990s are related to improved stream conditions, although they were not able to determine the precise magnitude of the changes. However, ongoing development and land-use activities are likely to continue to have negative effects (NMFS 2016b).

Many tributary habitat improvement actions have been implemented throughout the Snake River basin through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies (BPA et al. 2013, 2016, 2020; NMFS 2016b, 2017a; BOR 2018, 2019b). The Action Agencies have been implementing tributary habitat improvement actions as part of mitigation for the CRS since 2007. These actions have been targeted toward addressing the limiting factors identified above, and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat (BPA et al. 2013, 2016, 2020). Cumulative metrics for these action types for SRB steelhead from the years 2007 to 2019 are shown in Table 2.3-9.

Table 2.3-9. Tributary habitat improvement metrics: SRB Steelhead, 2007 to 2019 (BPA et al. 2020, McLaughlin 2020).

Action Type*	**Amount Completed**
Acre-feet/year of water protected (by efficiency improvements and water purchase/lease projects)	93,889
Riparian acres protected (by land purchases or conservation easements)	3,522
Riparian acres improved (to improve riparian habitat, such as planting native vegetation or control of noxious weeds)	8,305
Miles of enhanced or newly accessible habitat (by providing passage or removing barriers)	1,404

Action Type*	Amount Completed
Miles of improved stream complexity (by adding wood or boulder structures or reconnecting existing habitat, such as side channels)	226
Miles protected (by land purchases or conservation easements)	233
Screens installed or addressed (for compliance with criteria or by elimination/consolidation of diversions)	90

*Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS has determined, based on best available science, that the actions implemented by the Action Agencies and other entities have improved, and will continue to improve, habitat in the targeted populations as these projects mature, and that fish population abundance and productivity will respond positively. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions). Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

RME has been underway for this DPS to evaluate changes in habitat and fish populations as a result of habitat improvement actions. Available empirical evidence supports our view that these actions are improving tributary habitat capacity and productivity, and that fish are responding. Below we include limited examples of RME results specific to SRB steelhead, while Appendix A summarizes the scientific foundation for our determination, including relevant RME information from throughout the Columbia River basin and other lines of evidence that we considered regarding the effects of habitat improvement actions. It also discusses the complexities of evaluating the effects of habitat restoration on fish populations (see Appendix A;

also see NMFS 2014a, Hillman et al. 2016, ISAB 2018, Griswold and Phillips 2018, Haskell et al. 2019).[100]

The best available scientific and technical information also indicates that there is additional potential to improve habitat productivity, although this varies by population. While in most areas, there appears to be adequate potential to improve habitat productivity, in some areas, the potential is more limited or uncertain (NMFS 2016b, 2017a). Strong density dependence has been observed in SRB steelhead populations (ISAB 2015), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stage and limiting factors, would be likely to improve overall population abundance and productivity.

Density dependence in populations spawning above Lower Granite Dam is illustrated in an analysis by the IDFG. The IDFG tracks adult and juvenile steelhead passing Lower Granite Dam and estimates abundance, composition, and productivity in the aggregate and by stock and MPG, using data from biological samples. They estimate freshwater productivity rates through brood-year cohort analysis and juvenile production potential using juvenile-to-female stock recruitment models (Camacho et al. 2019a, 2019b). Their data show density dependence in the relationship of juvenile production to females available for natural reproduction (Figure 2.3-7).

[100] The goal of the tributary habitat program is to implement tributary habitat actions that address priority limiting factors and improve population abundance, productivity, spatial structure, and diversity. Measuring the effects of habitat restoration for fish and other aquatic and riparian biota is “one of the great challenges of river and stream conservation” (ISAB 2018). To draw conclusions about the benefits of tributary habitat improvements, we evaluated multiple lines of evidence, including knowledge of the basic relationships between fish and their tributary habitat, findings in the scientific literature about how changes in fish habitat affect fish populations, literature on the physical and biological effectiveness of tributary habitat improvement actions, correlation analyses, results from monitoring in the Columbia River basin designed to evaluate the effects of various actions on tributary habitat limiting factors and on salmon and steelhead population response, and the results of life-cycle models. Those lines of evidence and our conclusions are summarized in Appendix A.

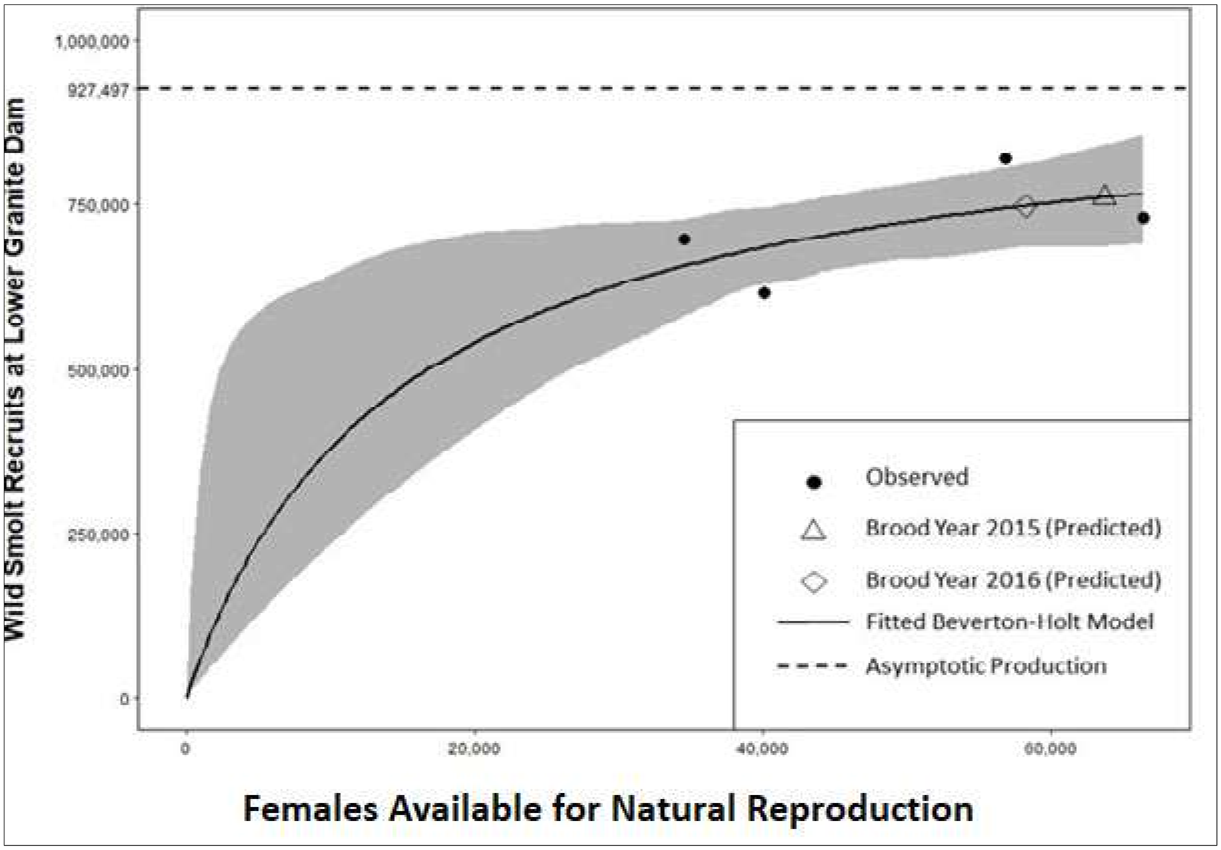

Figure 2.3-7. Comparison of observed wild juvenile steelhead abundance at Lower Granite Dam and females of all rear types available for natural reproduction upstream of Lower Granite Dam for brood years 2011 to 2014. The Beverton-Holt stock-recruitment model's prediction of juvenile production for brood years 2015 and 2016 is included for comparison. The shaded area represents the 95 percent confidence interval for the fitted model (Camacho et al. 2019b)

Figure 2.3-7 shows that there appears to be a limitation on the number of juveniles that the habitat is able to produce upstream of Lower Granite Dam (less than 1 million steelhead smolts) when the number of female spawners ranged from about 35 to 65 thousand. As more data become available, this relationship will become more refined. Camacho et al. (2019b) note that there are multiple potential explanatory hypotheses for this pattern, including loss of habitat, loss of marine-derived nutrients, habitat fragmentation, high temperatures, competition with hatchery fish, and others. Overall, these data are consistent with ISAB (2015) and support the concept that improvements in tributary habitat capacity or productivity, if targeted at limiting life stages and limiting factors, would likely improve overall population abundance and productivity.

More detail on tributary habitat conditions for the five extant MPGs (and 24 extant populations) that constitute this DPS is provided below.

2.3.2.4.2 Salmon River MPG

The Salmon River MPG historically supported 12 SRB steelhead populations: the Little Salmon River, Chamberlain Creek, Secesh River, South Fork Salmon River, Panther Creek, Lower Middle Fork Salmon River, Upper Middle Fork Salmon River, North Fork Salmon River, Lemhi

River, Pahsimeroi River, East Fork Salmon River, and Upper Mainstem Salmon River. All of these populations are extant (NMFS 2017a).

Good to excellent steelhead habitat conditions exist in most sections of this MPG that are included in the Frank Church—River of No Return Wilderness. This wilderness area covers most of the Upper Middle Fork Salmon River, Lower Middle Fork Salmon River, and Chamberlain Creek population areas, and parts of the South Fork Salmon River and Panther Creek population areas. Other habitat in these population areas also lies primarily under U.S. Forest Service management (NMFS 2017d).[101]

The remaining steelhead populations in this MPG contain a mix of public and private lands. Habitat conditions vary across and within these populations. All retain some areas of high-quality steelhead habitat but all also contain degraded areas as a result of mining, agriculture, grazing, forest management, recreational use, and road development. Steelhead habitat for the Secesh, Little Salmon River, and North Fork Salmon River populations is mostly on Federal lands and generally highly productive, although there are legacy (and some ongoing) impacts. The Lemhi and Pahsimeroi subbasins have been highly degraded by livestock grazing and instream flow alterations, including tributaries that have been disconnected from the mainstem. The East Fork Salmon River habitat has also been degraded considerably by similar land uses. In the Upper Salmon River population, the extent of habitat degradation varies from extensive (e.g., in the Yankee Fork) to less extensive (NMFS 2017d). The land uses in these areas have reduced riparian function and floodplain connectivity, increased sediment loading, reduced summer base flows, disconnected tributaries from mainstream rivers, elevated summer water temperatures, and reduced instream habitat quality complexity in some areas. Passage barriers continue to restrict steelhead passage to historical habitat in each population area. In several population areas, unscreened irrigation diversions entrain juvenile steelhead into irrigation canals, where they become trapped. Presently, some degraded areas are likely on an improving trend due to ongoing habitat restoration efforts (NMFS 2017d).

Restoration actions in this MPG have included fencing and riparian area planting and streambank restoration; road obliteration, decommissioning, and other road-related actions to reduce sediment input into streams; culvert removal or replacement; floodplain and stream channel restoration; reconnecting tributaries to mainstems; screening and modification of water diversions; habitat protection through acquisitions, conservation easements, and other methods; and cessation of certain land use activities in some areas to allow habitats to recover (BPA et al. 2013, 2016, 2020; NMFS 2016b, 2017d). For example:

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[101] Even in the wilderness area habitats, however, some small, localized areas display degraded habitat conditions associated with road development, past mining, livestock grazing, irrigation diversions, timber harvest, off-highway vehicles, and other recreational use. Some amount of degradation also has occurred on private lands. These localized limitations include impacts to passage, flow, sediment inputs, riparian area function, and nutrient supply. In addition, loss of beavers has led to channel simplification.

- In the Lemhi River, insufficient instream flow, loss of access to historically important habitat, and simplification of mainstem habitat were the primary limiting factors for Chinook salmon and steelhead productivity (ISEMP/CHaMP 2015, 2016). Twenty-two types of habitat improvement actions were planned in high-priority watersheds. To date, tributary water diversions have been replaced with mainstem diversions, allowing tributaries to be reconnected to the mainstem, reducing total water withdrawals, and allowing cooler tributary water to enter the mainstem Lemhi River. In addition, tributary passage conditions have been improved, providing access to relatively intact public lands. The reconnection of tributaries to the Lemhi River has nearly doubled the length of stream available to steelhead (ISEMP/CHaMP 2016). Minimum instream flow agreements have addressed passage impediments and reduced temperatures in the upper mainstem Lemhi River. Overall, restoration has resulted in a 22 percent increase in wetted stream area and a 19 percent increase in pool habitat in the Lemhi River basin compared to pre-treatment conditions. Adult steelhead have moved into each of the five reconnected tributaries, and these tributaries are producing anadromous juveniles (Hillman et al. 2016, Haskell et al. 2019).
- In the South Fork Salmon River drainage, over 150 miles of road prisms have been fully obliterated since 2009. In addition, improvements to the open road system (e.g., graveling, stabilizing crossings, replacing fords with bridges or culverts allowing aquatic organism passage, installing drainage features, etc.) have been implemented to reduce sediment delivery (NMFS 2016b).
- Eleven fish passage barriers in the South Fork Salmon River basin were replaced with crossings allowing for aquatic organism passage, restoring access to over 20 miles of habitat (NMFS 2016b).
- In the Little Salmon River drainage, five culvert barriers have been replaced with structures allowing access to about 6 miles of habitat (NMFS 2016b).

These actions have been targeted toward addressing limiting factors, and best available science indicates that they have improved, and will continue to improve, habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. The benefits of some of these actions will continue to accrue over several decades (see Appendix A).

The Action Agencies' efforts for this MPG under the 2008 and 2019 biological opinions were focused on the Lemhi, Pahsimeroi, and Salmon River Upper Mainstem populations, where they implemented substantial habitat improvement actions (BPA et al. 2016, 2020). In addition, smaller improvement actions were implemented for the Lower Middle Fork Mainstem, East Fork Salmon River, Secesh River, and South Fork Salmon River populations. Of the populations for which the Action Agencies implemented actions, the Lower Middle Fork and South Fork Salmon River populations must achieve viable or highly viable status to achieve ESA recovery goals, and the Lemhi, Pahsimeroi, Upper Salmon River Mainstem, East Fork Salmon River, and Secesh River populations must achieve viable or maintained status (NMFS 2017a).[102]

In summary, habitat for the Salmon River MPG includes some populations with very high-quality habitat due to the preponderance of wilderness areas and other Federal lands, and some populations with highly degraded habitat areas or a mix of habitat quality. While some degraded areas in the Salmon River MPG are likely on an improving trend due to ongoing improvement efforts and improved land use practices, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of this MPG. Potential for improvement varies across populations from low or uncertain to high, and additional improvements are needed to achieve recovery goals. Ongoing land-use activities are likely to continue to have negative effects.

2.3.2.4.3 Grande Ronde River MPG

The Grande Ronde River MPG historically supported four SRB steelhead populations: Joseph Creek, Wallowa River, Upper Grande Ronde River, and Lower Grande Ronde River. All four populations are extant (NMFS 2017a).

Habitat conditions vary across these four extant populations. Much of the habitat for the Wallowa River population is in designated wilderness areas, some is in near pristine condition, although some effects from past land use linger, and some valley floor reaches are more modified. Habitat for the Joseph Creek population is generally high quality but has been affected by road development, grazing, historical forest management, and agricultural practices. Habitat for the Upper Grande Ronde River population is highly impaired, particularly in valley bottoms, which are privately owned and support grazing and irrigated agriculture. In the Lower Grande Ronde River, headwater streams generally have high road densities, and lower elevation areas are heavily affected by livestock grazing and irrigated agriculture. The Lower Grande Ronde River also serves as a migration corridor and overwintering area for juvenile summer steelhead from other populations in this MPG. Fish that leave upriver areas in fall and spring continue rearing within the lower basin for 6 months to several years before resuming migration (NMFS 2017e).

The combined effect of the land uses in these subbasins—including agriculture, forestry and grazing practices; dams and other barriers; water withdrawals; and roads and channel manipulations—has contributed to high summer water temperatures, excess fine sediment, alteration of flow (primarily low summer flows), a lack of habitat complexity (e.g., pools and large wood), degraded riparian conditions, and impaired passage. Many reaches also suffer from impaired riparian conditions and loss of floodplain connectivity, which contribute to the above

[102] For ESA recovery, at least six populations in this MPG must be viable (low risk); one of these populations must be highly viable. Considering other factors such as size and life-history diversity, the Little Salmon, Secesh, Panther Creek, North Fork, Lemhi, Pahsimeroi, East Fork, and Upper Salmon River populations must achieve viable or maintained status, and the South Fork Salmon, Lower Middle Fork, Upper Middle Fork, and Chamberlain Creek populations must achieve viable or highly viable status.

conditions. Habitat conditions in the Grande Ronde River migration corridor (which also serves as rearing habitat), are also limited and affect primarily juvenile rearing and migration (NMFS 2017a).

Many restoration activities have been carried out in this MPG by the individual and combined efforts of Federal, state, tribal, local, and private entities, including the Action Agencies. Actions have been targeted toward addressing the identified limiting factors and have included flow enhancement and protection, screening of irrigation diversions, passage improvements, improved channel complexity, floodplain reconnection, and riparian protection and improvement (BPA et al. 2013, 2016, 2020).

Over time, these actions have been increasingly strategically targeted to address the limiting factors, and this should improve their effectiveness. For instance, Reclamation has completed tributary assessments in the Upper Grande Ronde River subbasin (BOR 2014) and Catherine Creek (BOR 2012). The Action Agencies have also funded and worked with local partners since 2011 to develop, implement, and adaptively manage the "Atlas" process, a systematic approach to identify and prioritize the actions that would be most likely to improve habitat. The Atlas process includes key elements from the watershed restoration principles articulated in Roni et al. (2002, 2008) and Beechie et al. (2008, 2010). It is a multi-criteria decision analysis framework that utilizes the best available empirical fish and habitat data; peer-reviewed, published research evidence; and local knowledge to determine the highest-priority areas and actions for habitat improvement within a watershed. It integrates GIS data relating to the limiting factors in an assessment unit to identify "biologically significant reaches," and results in scored restoration opportunities displayed on a map within a hierarchical spatial framework (Booth et al. 2016). The process builds on the tributary and reach assessments and other available data and information and is intended to improve the ability to identify opportunities for habitat improvement actions that address limiting factors. The Atlas process and other assessments have contributed to an enhanced understanding of habitat conditions and functions and of the potential for improvement in the studied reaches; together, these tools are improving the Action Agencies' abilities to target habitat improvement actions where they will provide the greatest benefits.

Multiple projects have now been completed under the Atlas framework. As an example, the Atlas process revealed that habitat improvement targeted in the CCC3a and CCC3b assessment units of Catherine Creek would provide the best opportunities to address limiting factors for that population. The Action Agencies and their partners have since focused implementation in those areas. The Southern Cross project, for instance, located in CCC3b, presented one of the most significant opportunities to restore core spawning and rearing habitat for spring/summer Chinook salmon and summer steelhead. The project's goal was to restore watershed processes and functions and address habitat limiting factors, including flow, passage, temperature, channel/floodplain conditions, habitat complexity and diversity, and riparian/wetland communities to improve summer and winter rearing conditions for juvenile salmonids and holding habitat for adult Chinook salmon. Completed in 2017, the project included acquisition of 545 acres (through the CTUIR-BPA Accord), realigning Catherine Creek into a sinuous, lower gradient channel connected to its historical floodplain, and constructing a network of floodplain swales and channels. Habitat features included large wood, constructed riffles, alcoves, and large pool habitat. The project created 4,200 linear feet of new main channel; 995 linear feet of perennial side channel; 425 linear feet of new ephemeral side channel; 1,425 linear feet of alcoves and spring channels; 9,200 linear feet of floodplain wetland complexes; and 15 riffles in the main channel. It also added 142 main channel wood structure components; 570 linear feet of edge roughness; 1,075 feet of brush mattress; and 336 floodplain roughness features. Monitoring by the Confederated Tribes of the Umatilla Indian Reservation has documented increased Chinook salmon and steelhead juvenile rearing densities in the project area since completion, and ODFW documented the highest juvenile chinook salmon rearing densities within the project compared to 10 sample locations distributed throughout core Catherine Creek anadromous fish spawning and summer rearing reaches (CTUIR 2018, 2019).

Best available science indicates that these actions have improved, and will continue to improve, habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. The benefits of some of these actions will continue to accrue over several decades (see Appendix A).

Under the 2008 and 2019 biological opinions, the Action Agencies' efforts in this MPG were focused on the Wallowa River, Joseph Creek, and Upper Grande Ronde River populations, with a small amount of work completed for the Lower Grande Ronde population (BPA et al. 2016, 2020). To achieve ESA recovery goals, the Upper Grande Ronde River population needs to be viable or highly viable; the Lower Grande Ronde and Wallowa River populations need to be either viable or maintained; and the Joseph Creek population needs to be viable, highly viable, or maintained (NMFS 2017a).

In summary, while some degraded areas in the Grande Ronde River MPG are likely on an improving trend as a result of ongoing habitat improvement efforts and improved land use practices, in general, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of this MPG. There is a high potential for improvement in habitat productivity for most populations in this MPG, and additional improvements are needed to achieve recovery goals. Ongoing land-use activities are likely to continue to have negative effects.

2.3.2.4.4 Lower Snake River MPG

The Lower Snake River MPG historically supported two SRB steelhead populations: Tucannon River and Asotin Creek. Both of these populations are extant (NMFS 2017a). To achieve ESA recovery goals, both populations must be viable, and one of them must be highly viable (NMFS 2017a).

In these subbasins, historical and current land use practices, including grazing and irrigated agriculture, logging, removal of beaver populations, roads, residential development, and diking, have led to excess fine sediment, diminished large wood supply, channel straightening and confinement, degraded riparian function, increased summer water temperatures, and diminished flows. Most water diversions without proper passage routes have been fixed but could still disrupt migrations of adult steelhead. Most unscreened diversions have also been fixed but could trap or divert juvenile steelhead and result in reduced survival. These factors have diminished habitat diversity and the availability of key habitat (in particular, summer rearing and overwintering habitat) and have negatively affected the abundance, productivity, and spatial structure of steelhead (Snake River Salmon Recovery Board 2011).

Many restoration activities have been carried out in this MPG in recent years by Federal, state, tribal, local, and private entities, including the Action Agencies. Actions have included large-scale efforts to enhance stream complexity and restore floodplain function and side-channel complexity through placement of logjams, riparian restoration, levee removal, and side-channel reconnection (Snake River Salmon Recovery Board 2011, NMFS 2014a; BPA et al. 2013, 2016, 2020). Best available science indicates that these actions have improved, and will continue to improve, habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. The benefits of some of these actions will continue to accrue over several decades (see Appendix A).

Under the 2008 and 2019 biological opinions, the Action Agencies implemented actions to benefit both the Tucannon River and the Asotin Creek populations (BPA et al. 2016, 2020). For instance, in the Asotin Creek population, from 2012 to 2016 more than 650 log structures were placed in the stream bottom as part of an experimental habitat restoration and monitoring design called the Asotin Creek Intensively Monitored Watershed. The addition of the wood structures was designed to add complexity to the streams and provide refuge for fish, especially juveniles. Early monitoring has documented a 28.8 percent increase in juvenile steelhead abundance in areas with the wood structures compared to those without, and modeling suggests that the carrying capacity of the streams has increased by 50 percent following addition of the log structures (Griswold and Phillips 2018).

In the Tucannon River basin, actions have been increasingly strategically targeted over time, primarily through the Tucannon River Habitat Programmatic Project, which BPA began funding in 2011. This effort has included development of the Tucannon Geomorphic Assessment and Restoration Study (Anchor QEA 2011) and additional restoration plans for specific reaches, and it has led to a more coordinated approach to restoration in priority reaches of the Tucannon River, with a focus on ameliorating lack of floodplain connectivity, loss of riparian forest and channel complexity, excess stream power, and a lack of large deep pools where adults can hold before spawning. These issues are the result of past floodplain management, including construction of levees that have confined and straightened the river and created incised channels throughout the watershed. Restoration actions have resulted in improving trends.

In summary, while some degraded areas in the Tucannon and Asotin subbasins are likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of this MPG. There is potential for improvement in habitat productivity in both populations, and additional improvements are needed to achieve recovery goals. Ongoing land-use activities are likely to continue to have negative effects.

2.3.2.4.5 Clearwater River MPG

The Clearwater River MPG historically supported six SRB steelhead populations: the Lower Mainstem Clearwater, the North Fork Clearwater, Lolo Creek, Lochsa River, Selway River, and the South Fork Clearwater populations. The North Fork Clearwater population is extirpated, and the remaining populations are extant (NMFS 2017a).

Habitat conditions in the Clearwater River MPG span a wide range of quality. Both historical and present-day land uses have significantly altered steelhead habitat in portions of the Clearwater River basin. Steelhead habitat has the fewest alterations at higher elevations that are managed primarily as forestlands, and in steeper canyons that are poorly suited for development. Steelhead habitat with the least amount of human alteration in the Clearwater River MPG lies in the Selway River, and parts of the Lochsa River, population areas. The Selway-Bitterroot Wilderness covers nearly all of the Selway River population area and some higher elevations in the Lochsa River drainage, providing protection from human impacts associated with roads. The Selway and Lochsa Rivers are also designated wild and scenic rivers. A large portion of the upper Lochsa River drainage outside the wilderness boundary has a checkerboard land-ownership pattern with alternating sections of U.S. Forest Service lands and private lands intensively managed for timber production (NMFS 2017d).

Habitat conditions for the Lolo Creek, South Fork Clearwater River, and Lower Mainstem Clearwater River populations contain a mix of public and private lands. Habitat conditions are not assessed for the North Fork Clearwater River steelhead population, which was extirpated by the construction of Dworshak Dam. While all of the extant population areas continue to contain some high-quality steelhead habitat, habitat degradation in many reaches has resulted from agricultural use, livestock grazing, timber harvest, road development, and past mining activities. In some areas, these land uses have reduced riparian function and floodplain connectivity, increased sediment loading, created passage obstructions, elevated summer water temperatures, and reduced instream habitat complexity. Habitat modification is greatest along valley bottoms in developed areas and in areas under intensive agricultural or timber management. Presently, some degraded areas are likely on an improving trend due to ongoing habitat restoration efforts (NMFS 2017d).

Restoration activities in this MPG have included riparian fencing and planting, road decommissioning and obliteration, culvert replacement, erosion control, barrier removals, dike removal and reconnection of streams to floodplains, stream structure enhancement, and acquisition of land and conservation easements (BPA et al. 2013, 2016, 2020; NMFS 2017d). These actions have been targeted toward addressing limiting factors, and best available science indicates that they have improved and will continue to improve habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. The benefits of some of these actions will continue to accrue over several decades (see Appendix A).

The Action Agencies' efforts for this MPG under the 2008 and 2019 biological opinions included work to benefit all five extant populations, with the most intensive efforts focused on the Lochsa, Lolo Creek, and South Fork Clearwater populations, with some actions also implemented to benefit the Selway and Lower Mainstem Clearwater populations (BPA et al. 2016, 2020). To achieve recovery under the ESA recovery plan, the Lower Mainstem Clearwater River, Lolo Creek, and Lochsa River populations need to be viable or highly viable, and the South Fork Clearwater and Selway River populations need to be viable or maintained (NMFS 2017a).

In summary, while some degraded areas in this MPG are likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of the populations in this MPG. There is potential for improvement in habitat productivity in all populations in this MPG, and additional improvements are needed to achieve recovery goals. Ongoing land-use activities are likely to continue to have negative effects.

2.3.2.4.6 Imnaha River MPG

The Imnaha River historically supported a single SRB steelhead population, which remains extant.

Over two-thirds of the Imnaha River basin is under public ownership. Factors potentially limiting summer steelhead in the Imnaha River include high stream temperatures, impaired riparian conditions, and excessive fine sediment. In addition, reduced large wood, low pool frequency and quality, poor water quality, and low flow conditions may be factors. These factors have the greatest effect on juvenile rearing. Limiting factors for this population primarily reflect stream channel and riparian area degradation resulting from past livestock grazing, timber harvest, and road construction, and low summer stream flows due to water withdrawals (NMFS 2017e).

Some restoration activities have been carried out in this MPG by the individual and combined efforts of Federal, state, tribal, local, and private entities, including the Action Agencies. The actions have improved habitat access and habitat complexity, and protected and improved riparian areas (BPA et al. 2016, 2020). Under the 2008 biological opinion, the Action Agencies implemented a limited number of improvement actions for this population to improve access, increase stream complexity, and reduce sediment by protecting riparian areas[103] (BPA et al. 2013, 2016, 2020). To achieve recovery under the ESA recovery plan, the single population in this MPG must be highly viable (NMFS 2017a).

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[103] Improved access to 20 miles, improved stream complexity (.12 miles), riparian improvement (.06 miles), riparian protection (251 acres) (BPA et al. 2013).

In summary, while some degraded habitat in this MPG is likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of the population in this MPG. There is potential for improvement in habitat productivity in this MPG, and additional improvements are needed to achieve recovery goals. Ongoing land-use activities are likely to continue to have negative effects.

2.3.2.4.7 DPS Summary

In summary, while tributary habitat conditions are likely improving in some areas as a result of habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect SRB steelhead abundance, productivity, spatial structure, and diversity. In addition, the potential exists to further improve tributary habitat capacity and productivity in this DPS, although the potential varies by population. Additional improvements are needed in almost all populations to achieve recovery goals. In addition, ongoing development and land-use activities are likely to continue to have negative effects.

2.3.2.5 Estuary Habitat

The Columbia River estuary provides important migratory habitat for yearling SRB steelhead. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review (NMFS 2016b), have improved access and connectivity to floodplain habitat. From 2007 through 2019, the Action Agencies implemented 64 projects including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents more than a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling steelhead (Johnson et al. 2018). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Floodplain habitat restoration can affect the performance of juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) are also exported to the mainstem and off-channel habitats behind islands and other landforms, where they become available to juvenile steelhead migrating in these locations. Thus, while most steelhead may not enter a tidal wetland channel, they still derive benefits from wetland habitats (PNNL and NMFS 2020). Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry. Blood serum levels of IGF-1 for yearling steelhead collected in the estuary were higher than are typically found in hatchery fish before release, suggesting that prey quality and quantity in the estuary were sufficient for growth (PNNL and NMFS 2020). However, variation in IGF-1 levels was substantial (two to three times higher in some individuals than in others) (Beckman 2020), both within and between genetic stocks, indicating differences in feeding and migration patterns. Continuing to grow during estuary transit may be part of a strategy to escape predation during the ocean life stage through larger body size.

As discussed in Section 2.3.2.1.2 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing the fact contaminants are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.3.2.6 Predation

A variety of avian and fish predators consume juvenile SRB steelhead on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. This section discusses predation rates and describes management measures to reduce the effects of the growth of predator populations within the action area.

2.3.2.6.1 Avian Predation

<u>Avian Predation in the Lower Columbia River Estuary</u>

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river’s estuary and plume is one-third of 19th-century levels

(Bottom et al. 2005). Reduced sediment discharge to the lower river, especially during spring, contributes to reduced turbidity, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including SRB steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. Roby et al. (2017) estimates that terns on East Sand Island consumed an average of 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island.

Based on PIT-tag recoveries at East Sand Island, average annual Caspian tern and double-crested cormorant predation rates for this DPS were about 25.3 and 7.2 percent, respectively, before efforts to manage the size of these colonies (Evans and Payton 2020). Tern predation rates have decreased to 10.7 percent since 2007, a statistically credible difference (Appendix B). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on SRB steelhead in 2003 to 2014 was 7.2 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge[104] where smolts are likely to constitute a larger proportion of the cormorants' diet. The average annual predation rates on SRB steelhead reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (6.8 during 2015 to 2017 and 0.5 percent in 2018) therefore cannot be directly compared to those before management began, and are likely to underestimate predation rates in the estuary.

Avian Predation in the Hydrosystem Reach

The following paragraphs describe avian predation in the mainstem lower Snake and Columbia Rivers from the tailrace of Bonneville Dam to the head of Lower Granite Reservoir.

[104] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

SRB steelhead survival in the mainstem is affected by avian predators that forage at the mainstem dams and reservoirs. The 2008 biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84 to 94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[105]

Juvenile SRB steelhead are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been focused on keeping terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015, and similar efforts by Reclamation are in progress at Goose Island. Predation rates on this DPS, which were 4.5 percent for terns on Crescent Island before implementation of the IAPMP, were reduced to less than 1 percent (predation rates for terns on Goose Island and North Potholes Island remained less than 0.1 percent) (Evans and Payton 2020) (Appendix B). However, the movement of terns to Blalock Islands in John Day Reservoir increased predation rates on SRB steelhead from 0.5 percent to 3.1 percent, indicating very little if any change in the likelihood of survival.

Predation by gulls was not considered to warrant management actions at the time the IAPMP was developed, and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this DPS by gulls on Miller Rocks averaged 7.2 percent during 2007 to 2019 (Evans and Payton 2020) (Appendix B). Predation rates on SRB steelhead were less than 2 percent for gulls nesting on Island 20 in recent years, but were higher than 2 percent on Badger, Crescent, and Blalock Islands (Evans and Payton 2020).

[105] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams" (Zorich et al. 2012).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on SRB steelhead after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts over estimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead, and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different although related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., had no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns. But the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, also will be important.[106]

With respect to management of terns and cormorants in the estuary, Caspian terns nesting on East Sand Island were eating an annual average of 25.3 percent of juvenile SRB steelhead outmigrants before management actions reduced the size of that colony, and 10.7 percent per year thereafter, a statistically credible difference (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (25.3 percent) and the average 14.6 percent per year decrease achieved by reducing the size of the tern colony, it is likely that this

[106] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

management measure led to increased adult returns for SRB steelhead, before the downturn in ocean conditions overwhelmed improvements in freshwater survival. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 7.2 percent to less than 1 percent, a small to moderate decrease. However, in this case, predation rates on SRB steelhead are likely to have increased because thousands of these birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[107]

2.3.2.6.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia and Snake Rivers followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). From 2015 to 2019, an annual average of 44 adults, and 165 juvenile steelhead were incidentally caught in the Sport Reward Fishery (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to DPS, we assume that some were SRB steelhead.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). No steelhead were reported as incidental catch over the last 5 years. In addition, they caught, but did not remove, an annual average of 967 smallmouth bass and 379 walleye at the two dam angling sites combined over the last 5 years (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). The Oregon and Washington Departments of Fish and Wildlife, which manage these two non-native predator species, are currently discussing the possibility of removing smallmouth bass and walleye from the system when captured by the Dam Angling Program (as with pikeminnow). Both agencies

[107] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

have already removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these species, in addition to pikeminnow, both in the lower Columbia River and the CRS reservoirs (i.e., hydrosystem reach), would incrementally improve juvenile salmonid survival during their migration to the ocean.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile steelhead, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. Williams et al. (2018) found a lower than average abundance (1990 to 2018) for northern pikeminnow in The Dalles and John Day Reservoirs along with a two to three times higher than average abundance for smallmouth bass and walleye in the same reservoirs. With the exception of the John Day forebay area, smallmouth bass abundance index values calculated for 2018 were the highest observed since 1990. Abundance index values provide a means to characterize relative predation impacts (Williams et al. 2018). Similarly, in 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP, as well as a substantial increase in their predatory impact in the lower Snake reservoirs since program design and implementation. Also compared to previous years, walleye were relatively abundant in both The Dalles and John Day Reservoirs during 2018 spring sampling, but few were encountered during the summer sampling. The greatest walleye abundance indices were observed in the John Day Dam tailrace and mid-reservoir, with the tailrace value being the highest recorded abundance to date (Williams et al. 2018). These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal still remains unclear. The complexity of inter-species interactions, combined with inter-reservoir variability and environmental variability, make this a difficult research question to answer without a more intensive sampling and evaluation program (Williams et al. 2018; Winther et al. 2019). However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the steelhead that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including SRB steelhead. As such, it likely continues to benefit the DPS.

2.3.2.6.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions, Steller sea lions, and harbor seals consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. ODFW counted the number of individual California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, from 1997-2017. Pinniped counts at the East Mooring Basin during September and October, when SRB steelhead are migrating, have generally increased and doubled from 2014 to 2016 (maximum count of 1,318 California sea lions in September 2015; Wright 2018).

Snake River steelhead adult migrants are vulnerable to pinniped predation throughout the lower Columbia River. Through an authorization under the Marine Mammal Protection Act, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019 respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between RM 112 and McNary Dam (RM 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

Estimates of steelhead predation by pinnipeds in the lower Columbia River estuary (i.e., downstream of the Bonneville tailrace) are not available for the fall time period. Instead, estuary monitoring efforts have focused on California sea lion predation on SR spring/summer Chinook salmon during January to May (e.g., Rub et al. 2019).

Steller sea lion presence in the Bonneville tailrace has increased in the last 6 years during the summer and fall when adult SRB steelhead are migrating (Tidwell et al. 2020). Steller sea lions in particular aggregate at the base of the dam in the fall when SRB steelhead are present. Between July 21 and December 31, 2017, Tidwell et al. (2018) documented an average of 14.5 Steller sea lions at Bonneville Dam, and during many sampling periods counted more than 20 individuals. During the same months in 2019, Tidwell et al. (2020) documented an average of 31.8 Steller sea lions with a peak of 53 individuals. A small number (range 0 to 5) of California sea lions have been observed in Bonneville Reservoir in recent years.

Due to the repeated entry of sea lions into the adult ladders at Bonneville Dam, the Corps began constructing physical exclusion devices in 2006 to block pinnipeds but allow fish passage. These sea lion excluder gates are installed at all eight ladder entrances at Bonneville Dam when SRB steelhead are present (FPP 2020). In addition, the Corps has installed smaller physical exclusion gratings on the 16 FOGs along the face of Powerhouse 2 that allow fish to enter the collection channel and pass via the Washington shore ladder. The sea lion excluder gates and FOGs successfully prevent pinnipeds from entering the adult fish ladders, and thus further minimize opportunities to prey on SRB steelhead.

The percentage of steelhead consumed during the fall and winter was estimated to be 1.5 percent in 2017 (Tidwell et al. 2019), and 1.6 percent of steelhead were estimated to be consumed in 2018 (Tidwell et al. 2020). Based on the timing of the observations in the study, between 1.5 and 1.6 percent is a reasonable range for the percentage of adult SRB steelhead consumed at Bonneville Dam by pinnipeds.

2.3.2.7 Research, Monitoring, and Evaluation Activities

The primary effects of the past and present CRS-related RME programs on SRB steelhead are associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME actions also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods that can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP’s RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass, and walleye throughout the system to evaluate the program’s effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from

RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were SRB steelhead. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the SRB steelhead DPS by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of SRB steelhead that have been handled (or have died) each year using the average take reported from 2016 to 2019. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of SRB steelhead associated with the Smolt Monitoring Program and the CSS were as follows:
    - Zero hatchery and zero natural-origin adults were handled.
    - Zero hatchery and zero natural-origin adults died.
    - 18,056 hatchery and 7,631 natural-origin juveniles were handled.
    - 32 hatchery and 10 natural-origin juveniles died.
- Average annual estimates for SRB steelhead handling and mortality for all other RME programs were as follows:
    - 11,241 hatchery and 3,339 natural-origin adults were handled.

- One hatchery and eight natural-origin adults died.
- 121,324 hatchery and 63,305 natural-origin juveniles were handled.
- 272 hatchery and 138 natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program has, on average, affected 21.6 percent of the natural-origin adult (recent, 5-year average) run (arriving at Lower Granite Dam) and 8.7 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically: trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects SRB steelhead.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the DPS level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.3.2.8 Critical Habitat

The condition of SRB steelhead critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized here in Table 2.3-10. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for SRB steelhead production have been weakened. Conditions in the hydrosystem reach were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for SRB steelhead have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.3-10. Physical and biological features of designated critical habitat for SRB steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development.	Tributary barriers (culverts, dams, water withdrawals, unscreened water diversions) have reduced access to freshwater spawning sites for most populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for most populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for most populations. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning sites for most populations. Diminished stream flow (water withdrawals, drought) has reduced the quantity and quality of freshwater spawning sites for most populations. Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced the quality of freshwater spawning sites for most populations. Many tributary habitat improvement actions implemented in the Snake River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to spawning habitat.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, natural cover.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater rearing sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced the quality of freshwater rearing sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations. Excessive sediment in streambeds (forest and agricultural practices) has reduced the quality of freshwater rearing sites for all populations.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Condition of the PBF
		Many tributary habitat improvement actions implemented in the Snake River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to rearing habitat.
Freshwater migration corridors	Free of obstruction and excessive predation, Adequate water quality and quantity and natural cover.	*Effects on migration corridor PBFs apply to all populations and MPGs of SRB steelhead.* Alteration of the seasonal flow regime in the Columbia and lower Snake Rivers with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderately negative effect in lower flow years. Alteration of the seasonal mainstem temperature regime in the lower Snake and Columbia Rivers due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in late summer and fall (hydrosystem development and operations).[1] This alteration has adversely affected the functioning of the migration corridor for adult SRB steelhead, which enter the lower Columbia River during summer. The Action Agencies release cold water from Dworshak Dam on the North Fork Clearwater River so that temperatures in the Lower Granite tailrace do not exceed 68°F and operates fishway cooling pumps at the tops of the adult fishways at Lower Granite and Little Goose Dams to prevent migration delays in the lower Snake River. Reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume (hydrosystem development), may have reduced "natural cover" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining). The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Condition of the PBF
		lubricants" where feasible. Increased exposure of juveniles to TDG in the lower Snake and Columbia Rivers and at least 35 miles below Bonneville Dam during involuntary[2] and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor for juvenile steelhead. The incidence of adverse effects (GBT in juveniles and adults) appears to have been small (1 to 2 percent) in recent years with TDG up to 120 percent. The existence and operation of the hydrosystem has reduced the safe passage PBF by creating conditions that delay and injure/kill some juveniles and a smaller proportion of adults in the migration corridor. However, the functioning of the safe passage PBF has increased substantially for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult steelhead during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past the dams or overwintering within the fish facilities or turbine units). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile steelhead because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems). Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for avian and fish predators in the tailraces of mainstem dams. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, propane cannons, and limited

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Condition of the PBF
		amounts of lethal take. Fish predation is addressed by dam angling at several dams. Delays of adults at the ladder entrances at Bonneville Dam has increased the risk of pinniped predation (excessive predation related to hydrosystem development and operation) in the migration corridor. Pinniped predation is addressed by the use of sea lion excluder devices at the fishway entrances at Bonneville Dam. Increased opportunities for avian predators to successfully forage in project reservoirs and tailraces (excessive predation).
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity and salinity, natural cover, juvenile and adult forage.	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling Chinook salmon by more than 2.5 percent. Another 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the Caspian Tern Management Plan on East Sand Island is reducing excessive predation on juvenile steelhead, but depending on ocean conditions and compensatory effects, may not be increasing adult returns for SRB steelhead. Implementation of the Double-crested Cormorant Management Plan may have contributed to, or at least coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island.
Nearshore marine areas[3]	Free of obstruction and excessive predation with water quality, quantity and forage.	Concerns about increased pinniped predation and adequate forage.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Spill is characterized as “involuntary” when water is spilled over a dam’s spillway because it cannot be stored in a reservoir behind the dam or passed through turbines to generate electricity, such as during maintenance activities, periods of low energy demand, or periods of high river flow. Involuntary spill is most common in the spring.

[3] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Habitat quality in tributary streams within the lower Snake River basin within the Interior Columbia Recovery Domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia Recovery Domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the Interior Columbia River Recovery Domain (NMFS 2016b). As discussed above, many tributary habitat improvement actions have been implemented throughout the Snake River basin by Federal, tribal, state, local, and private entities. The Action Agencies' tributary habitat program has been protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. These actions are improving the condition of PBFs in specific locations.

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable spawning and rearing habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use, and periodic droughts have all contributed to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016b). They can negatively impact critical habitat and the organisms associated with these areas.

The general effects of tributary dams on the functioning of critical habitat in spawning and rearing areas and migratory corridors for SRB steelhead are:

- Lost access to historical spawning areas behind dams built without fish passage facilities (reduced safe passage).
- Altered juvenile and adult passage survival at dams with passage facilities (reduced safe passage).
- Altered flows and seasonal timing (reduced water quantity).
- Altered seasonal temperatures and elevated dissolved gas (reduced water quality).
- Reduced sediment transport and turbidity (reduced water quality).
- Altered food webs, including both predators and prey (reduced prey production and increased numbers of predators, including non-natives).

Habitat quality of migratory corridors in this area was substantially affected by the development and operation of the CRS dams and reservoirs in the mainstem lower Snake and Columbia

Rivers, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and upper Columbia River basins. Hydrosystem development modified natural flow regimes, resulting in warmer late summer/fall water temperatures. Changes in fish communities led to increased rates of piscivorous predation on juvenile salmon and steelhead. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines, have delayed migration for both adults and juveniles. Turbines and juvenile bypass systems have also killed some out-migrating fish (NMFS 2016b). However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented measures in the juvenile and adult migration corridor including 24-hour volitional spill, surface passage routes, upgrades to juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

In addition, basinwide water management activities, including the operation of the CRS water storage projects for flood control, power generation, and water withdrawals have substantially reduced average monthly flows at Bonneville Dam during May to July and increased them during October to March compared to an unregulated system. Reduced spring flows, combined with the existence of mainstem dams, increased travel times during the juvenile outmigration period for SRB steelhead, increasing the risk of predation. Since salmon and steelhead were listed and critical habitat was designated under the ESA, the Action Agencies have made substantial changes to minimize these operational effects by limiting storage reservoir elevations to minimums needed for flood risk management and passing more water during the spring refill period. By taking these actions, the Action Agencies have increased flows in the spring and summer, which helps replicate the natural hydrograph. As a result, the functioning of the migration corridor has been improved by reduced exposure to predators, increased turbidity (which can provide visual cover), and increased access to cover and prey in nearshore mainstem habitat.

The functioning of juvenile rearing and migration habitat for SRB steelhead in the lower Columbia River estuary has been reduced by the conversion of more than 70 percent of the original marshes and spruce swamps to industrial, transportation, recreational, agricultural, or urban uses. Water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. Reduced sediment delivery to the lower river and estuary, combined with in-water structures that focus flow in the navigation channel and bank armoring, have altered the development of habitat along the margins of the river. All of these changes have reduced the availability of prey for smolts between Bonneville Dam and ocean entry.

In the hydrosystem reach, altered habitats in project reservoirs and tailraces create more favorable habitat conditions for fish predators; the latter include native northern pikeminnow and non-native walleye and smallmouth bass. The effects of the non-native species and those of pikeminnow, to the extent they are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea lion predation on adult SRB steelhead in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary has increased, but is a natural phenomenon and therefore not excessive predation in the context of an effect on the functioning of critical habitat.

Restoration activities in tributary spawning and rearing areas and in the estuary that are addressing habitat quality and complexity, and improved functioning of the juvenile migration corridor (e.g., 24-hour and flexible spill, new surface passage structures, and improved spillway designs) have improved the baseline condition for some components of the PBFs. However, the role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the DPS. More restoration is needed before the PBFs can fully support the conservation of SRB steelhead.

2.3.2.9 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year status review evaluated new information regarding the status and trends of SRB steelhead, including recent biological opinions issued for the SRB steelhead, and key emergent or ongoing habitat concerns (NMFS 2016b). From January 2015 through May 22, 2020, we completed 595 formal consultations that addressed effects to SRB steelhead.[108] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation, and the consultation on the 2018 to 2027 *U.S. v Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

[108] PCTS data query July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

Some of the projects will improve access to blocked habitat, improve riparian conditions, and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., safe passage in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.3.2.10 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of SRB steelhead populations. Recent improvements in passage conditions at mainstem CRS dams, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, tributary habitat improvements, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. The recovery plan identified tributary and estuary habitat degradation, hydropower systems, harvest, hatcheries, predation, toxic contaminants, climate change, and fluctuating ocean cycles as limiting factors that continue to negatively affect SRB steelhead populations (NMFS 2017a).

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for SRB steelhead, as described above. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of these critical habitat PBFs. For example, surface passage structures and spill operations have reduced obstructions for juvenile SRB steelhead at CRS dams.

Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. Similarly, projects that have protected or restored tributary habitat have improved the functioning of the freshwater spawning and rearing sites. However, the factors described above continue to have negative effects on these PBFs.

2.3.3 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.3.3.1 Effects to Species

2.3.3.1.1 Spill and Seasonal Flow Operations

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams. The intent of flexible spill operations is to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem.[109] Spring spill operations will occur from April 3 to June 20 at the four lower Snake River projects and from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, the four lower Snake River dams and McNary Dams will all operate up to 125 percent TDG spill ("gas cap spill") for a minimum of 16 hours per day, and each project may operate under lower spill levels ("performance standard spill") for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill at all hours. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs maximum spill constraint) for 16 hours per day with 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours; however, once the trigger for adult SR spring/summer Chinook salmon

[109] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

passing Lower Monumental Dam is met,[110] 8 consecutive hours of performance standard spill will be used in the morning at Little Goose Dam to help reduce passage delays of adult SR spring/summer Chinook salmon.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan, unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in performance standard spill periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.3-11.

Table 2.3-11. Spring spill operations at lower Snake and Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3, 5]	Performance Standard Spill (8 hours per day)[2, 4, 5]
Lower Granite[5]	125% Gas Cap	20 kcfs
Little Goose[6, 7]	125% Gas Cap	30%
Lower Monumental	125% Gas Cap (uniform spill pattern)	30 kcfs (bulk spill pattern[8])
Ice Harbor	125% Gas Cap	30%
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[9]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[10]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[110] A passage trigger of 25 adult SR spring Chinook passing Lower Monumental Dam was implemented in 2020 per the Flexible Spill Agreement.

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility (with the exception of Little Goose and Lower Granite operations described in the notes that follow). Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions, except as noted below.

[5] Lower Granite Exception One - If adult passage delays are observed at Lower Granite Dam, the Corps may implement performance standard spill at Lower Granite Dam for at least 4 hours in the AM (beginning near dawn). Implementation of this modification may also trigger in-season reevaluation of options to balance power principle.

[6] Little Goose Exception One - As soon as practicable (and, in any event, no more than 24 hours) after a cumulative total of 25 adult spring Chinook salmon (not including jacks) pass Lower Monumental Dam, operate Little Goose spill at 30 percent spill for 8 consecutive am hours (April 1 to 15, start at 5 AM; April 16 to June 20, start at 4 AM).

[7] Little Goose Exception Two - During periods of involuntary spill, spill at 30 percent for 8 hours/day during the hours described in footnote 6 above and store additional inflows that exceed hydraulic capacity in the forebay above MOP if necessary. When it is necessary to pond water to achieve the lower spill levels due to high inflow, water stored above MOP should be drafted out over the remaining hours by increasing spill to pass inflow from 1200 to 1600 hours (or 1300 to 1700 hours from April 3 to 15), then increasing spill as necessary from 1600 to 0400 (or 1700 to 0500 hours from April 3 to 15) to draft the pool back to MOP. If it is forecast that the drafting spill will generate TDG levels in the tailrace in excess of 130 percent TDG, use all 16 hours to return the pool to MOP.

[8] If the specified spill level at bulk pattern exceeds the gas cap, then spill pattern will be changed to uniform.

[9] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[10] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 21 to August 31 at the four lower Snake River projects, and June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.3-12. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.3-12. Target summer spill levels at lower Snake and lower Columbia River projects.

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
Lower Granite[2,3]	18 kcfs	Removable spillway weir or 7 kcfs
Little Goose[2,3]	30%	Adjustable spillway weir or 7 kcfs

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
Lower Monumental[2,3]	17 kcfs	Removable spillway weir or 7 kcfs
Ice Harbor[2,3]	30%	Removable spillway weir or 8.5 kcfs
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[4]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] Spill levels may not be achievable on all hours if water is stored or flows are below 20 kcfs, which can occur in the month of August, especially at Lower Granite and Lower Monumental Dams when flows are at or below 30 kcfs (see FOP for additional information).

[3] Summer spill from August 15-August 31 may be through the spillway weir or through conventional spillbays using the appropriate FPP spill pattern for each project. The spillway weirs will be operated consistent with operational criteria in the FPP.

[4] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March, decreased flows from May through August, and little change in flows in April and September) described in the environmental baseline will continue to affect the lower Snake and lower Columbia mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak Reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to

2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in all project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce high TDG events associated with spill in the winter, which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. The proportional effect on flow is higher in the lower Snake River than in the lower Columbia River due to its smaller flow volume. However, the proposed operation is expected to occur only in the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.3-8).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

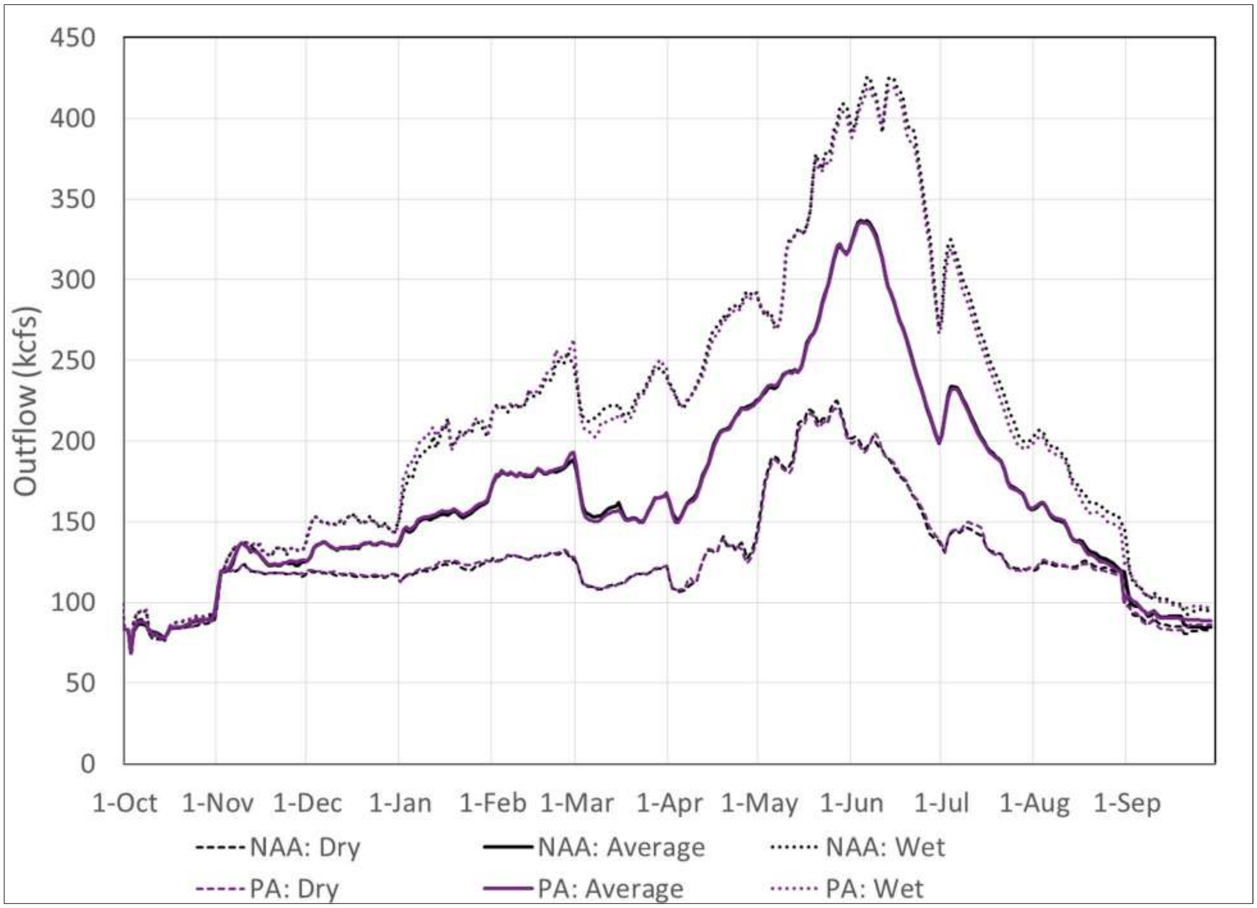

Figure 2.3-8. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

Juvenile SRB steelhead migrate through the lower Snake and Columbia Rivers primarily in April and May, and the Action Agencies will operate to meet seasonal flow objectives to support juvenile migrants during that period. Adult SRB steelhead enter the Columbia River primarily from June to August, may hold temporarily in cooler tributaries during the summer, and most adults pass Lower Granite Dam by fall. The proposed change in flow would be too small to affect river temperature during summer, which would be the attribute of highest concern. The associated effects on SRB steelhead smolts or adults should not change from recent conditions by a meaningful amount.

The effects of the proposed hydrosystem operations and the non-operational measures on SRB steelhead and its habitat are described below.

2.3.3.1.2 Water Quality

The operation of the CRS will continue to affect water quality parameters in the mainstem migration corridor. This includes delayed spring warming, delayed fall cooling, reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs, and the continued releases of cool water from storage at Dworshak Dam to moderate lower Snake River water temperatures from June through September.

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacity spill. These events will continue to occur most frequently in May and June but may also occur in other months.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in loss of equilibrium, increased predation, injury, and death (Weitkamp and Katz 1980). The proposed flexible spill operation would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. Individuals from all populations and MPGs would be exposed similarly. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020). Evidence suggests depth protects *Oncorhynchus mykiss* from GBT by approximately 10 percent TDG supersaturation per meter depth, and there is evidence for depth compensation behavior by fish in TDG supersaturated water which may alleviate GBT (Pleizier et al. 2020). However, steelhead smolts are known to migrate nearer the surface than other species, meaning they should be more exposed to higher TDG levels than other species. Data from all fish sampled in the CRS Gas Bubble Trauma Monitoring Program (1996 to 2019) indicate that signs of GBT were almost non-existent below 120 percent TDG, increased slightly between 121 percent and 125 percent TDG, and then increased in incidence and severity when TDG levels exceeded 125 percent (FPC 2019). The available information in Zabel (2019) and Widener et al. (2020) suggests that the relatively high TDG exposure often exceeding 125 percent during high flow years (e.g., 2006 and 2011) did not reduce smolt survival through the CRS. Thus, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (likely not measurable based on reach survival studies) increase in mortality of juvenile SRB steelhead.

Adult SRB steelhead typically migrate between Bonneville and Lower Granite Dam during the late summer and fall. About 2.1 percent of the DPS (4.0 percent of the unclipped natural-origin steelhead) hold up in the larger rivers over the winter, and then continue upstream through the mainstem dams in the spring. Thus, only a small portion of the DPS (approximately 2 to 4 percent of overwintering adults on average) would be exposed to the increased spill associated with the flexible spill operation. Adults also migrate at depths which reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[111] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on SRB steelhead are likely to be very small and are not expected to detectably affect reach survival estimates.

Sediment Transport

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency increases the exposure of SRB steelhead

[111] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile SRB steelhead spend only days to weeks in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

2.3.3.1.3 Project Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems (BPA et al. 2020). Maintenance activities evaluated and covered under this opinion can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance, as summarized in Section 1.3 of this opinion and in further detail in BPA et al. (2020).

Fishway structures (e.g., fish ladders, screens, bypass systems) will be routinely maintained and temporarily removed from service on a scheduled basis during the established in-water work period (December to March), in accordance with the Fish Passage Plan and coordinated through FPOM to minimize impacts to adult and juvenile migrants. At Bonneville Dam, routine dredging in the forebay and rock removal in the spillway will occur every year or two to ensure reliable operation and structural integrity of the fishways. Turbine unit maintenance is planned at all dams and will be coordinated through FPOM to minimize and avoid delay, injury, and mortality.

Routine outages of fishways are necessary to maintain reliability, but these temporary outages can cause delay and mortality for adult and juvenile migrants that attempt to migrate at the time of the outage. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of, SRB steelhead that are migrating, and these effects will occur at extremely low levels similar to what was observed in the recent past. Passage delay and conversion rates will be monitored and maintenance schedules may be modified through FPOM or adaptive management if evidence indicates elevated delay and mortality are occurring.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization and major rehabilitations. Non-routine maintenance expected in the timeframe of the proposed action includes the installation of improved fish passage (IFP) turbines at three out of six turbine units at Ice Harbor Dam. At McNary Dam, turbine replacement is expected to begin within the next 15 years. At John Day Dam, turbine replacement may begin, but it is uncertain at this time if it will be completed, within the 15-year period of the proposed action. The proposed maintenance at

Grand Coulee could result in outages and additional spill in limited situations, but changes to total outflows are not expected. The Corps will repair the existing jetty and retaining wall located near the north shore adult ladder entrance at Little Goose Dam, where significant erosion has occurred. Replacing the jetty with large rock and/or large coffer cells will restore passage conditions to pre-2011 levels at the north shore ladder entrance when spill exceeds 30 percent at Little Goose Dam. Non-routine maintenance (related to turbines or spillbays) expected in the proposed action can increase TDG during uncontrolled spill by temporarily reducing powerhouse capacity and may cause suboptimal tailrace conditions which can delay passage. The installation of IFP turbines will likely improve turbine survival and reliability once completed. Repairing the jetty at Little Goose Dam will likely reduce delay for adults and improve passage conditions when spill exceeds 30 percent. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce risk to adults and juveniles.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated with NMFS and through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize negative effects on fish. Fish passage metrics will be monitored with counts and PIT tags to ensure unscheduled maintenance activities do not result in negative impacts to the ESU.

Overall, scheduled maintenance activities are expected to continue to negatively affect small numbers of adult SRB steelhead annually. A few adults will be delayed or die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. Very few juveniles will likely be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult SRB steelhead will likely continue to result in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes will continue to minimize the impacts.

2.3.3.1.4 Adult Migration/Survival

Adult survival rates for Snake River steelhead are expected to continue to average about 94 percent from Bonneville to McNary Dam and 87 percent from Bonneville to Lower Granite Dam under the proposed action. The great majority of Snake River steelhead migrate after the flexible spring spill operation has ended. For those few adults that overwinter in the lower Columbia and

Snake Rivers and continue migrating upstream the following spring, tailrace conditions at John Day Dam and the lower Snake River Dams during low to moderate flows could be degraded by the increased spill levels (16 hours per day) resulting from the flexible spill operation during the spring spill period. While this operation could negatively affect passage conditions for migrating adults (i.e., the ability to find fishway entrances), eight hours of performance level spill should be sufficient to prevent any measurable impacts to passage or adult survival. The flexible spill operations should not negatively affect passage conditions for Snake River steelhead at the other CRS dams. Keefer et al. (2016) estimated that mean annual fallback rates were about 6 to 9 percent at the lower Columbia River dams, and 3 to 6 percent at the lower Snake River dams. Fallback rates, which are associated at many dams with higher spill levels, are likely to increase slightly for fish migrating during the spring spill period at several of the eight mainstem dams, but this effect will be small because few adult SRB steelhead will be present. For those few SRB steelhead exposed in the spring, the additional fallback would most likely happen through a spillbay (rather than a turbine unit or screened bypass system), which would be expected to increase the survival of these fish, relative to the other passage routes (Colotello et al. 2013, Normandeau et. al. 2014). This would potentially offset some of the potential impact of increased fallback rates associated with increased spill levels under the proposed action. Fallback is likely to be reduced for adult SRB steelhead migrating from August 15 to 31 during the reduced summer spill period, and some migrants may be more likely to fall back through powerhouse routes with lower survival probabilities. Adaptive management processes can be used to identify (daily or weekly estimates of fallback—reascension rates) and remedy (through in-season management processes) excessive fallback or migration delays, if it occurs, as was done for adult delays at Little Goose Dam in recent years. In addition, the Action Agencies will continue to handle hundreds of adult SRB steelhead at Lower Granite Dam during any emergency trapping operation for SR sockeye salmon. We expect that less than 1 percent of the steelhead run will be handled in a given year with no more than 10 mortalities; emergency trapping is likely infrequent and has only occurred in 1 year (2015) since the Snake River dams were constructed.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The majority of adult SR steelhead migrate after the spring spill period and will not be affected by the spring spill operation. Adults that do not enter the tributaries prior to the start of flexible spring spill operations (April 3 at the Snake River projects or April 10 at the lower Columbia River projects) would be exposed to increased TDG levels. Adults also migrate at depths that reduce the effective exposure to TDG through depth compensation mechanisms.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. This change will affect adult SR steelhead that may be migrating after that date in August by improving adult ladder attraction conditions and reducing fallback. However, individuals that fell back would experience greater risk because they would be more likely to pass via turbines and juvenile bypass systems instead of the spillway. A substantial portion of SR steelhead will be migrating when this occurs. While spill will be reduced during this period compared to baseline, a spillway route will be provided for fish that intend to fall back. The available information on steelhead fallback indicates adult steelhead prefer to utilize spillway routes over turbine routes if made available, and the reduced amount of spill provided in late August will still be sufficient for effective attraction and passage survival (Ham et al. 2012). Based on the correlation between spill and fallback rates, the overall operation is likely to lead to a minor reduction in project fallback rates, with the possibility of a very small increase in turbine passage. This is likely to result in a small positive effect for adults or no net measurable change in survival. Available data including PIT detections, fallback rates, conversion rates, and adult counts will be actively monitored for adaptive management.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14. Upstream travel times are highly variable for adult steelhead, which alter their behavior in response to temperature conditions and, potentially, other environmental cues. Individuals can take from less than 2 weeks to many months to migrate from Bonneville to Lower Granite Dam, sometimes holding in cool-water refuges or overwintering. Operating to MOP with a 1.5 foot operating range at the lower Snake River dams will have relatively little effect on travel time, and thus is not expected to measurably affect adult migration timing or survival rates.

The Action Agencies propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP (262.5 to 264.5 feet), except during the spring spill period, when the John Day forebay operating elevation window will be increased. From April 10 to June 1–15, John Day Reservoir elevation will be held between 264.5 feet and 266.5 feet to deter piscivorous Caspian terns from nesting in the Blalock Islands Complex (see Section 2.2.3.1.10). Following this operation, John Day Reservoir elevation would return to MIP + 2 feet operation through August 31. The increase in operating range is expected to slightly reduce velocities in John Day Reservoir, but the velocity change is not expected to affect adult migration timing or survival rates.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. PIT-tag data and adult count data indicate that the majority of adult SR steelhead are not actively migrating at night or during the day between December 15 and February 28. For the small percentage of adult steelhead that may migrate during the no flow period, this operation is likely to increase delay for fish attempting to migrate to spawning or holding areas. The Fish Passage Plan allows for the lower Snake River fish ladders to dewater for winter maintenance during the December 15 to February 28 period, so upstream migration through the Snake River Dams during this period is not possible.

The proposed operations at Libby Dam, Hungry Horse Dam, Grand Coulee Dam, and Dworshak Dam should not measurably affect adult migration or survival because the flow alterations in the Columbia River are relatively small (less than 2 kcfs measured at Bonneville Dam—see discussion above) during the months when these fish migrate. The small reduction of flow would not be sufficient to affect river temperature, which would be the most relevant effect influencing adult migration success. The proposed operation at Dworshak Dam should not affect adults because any potential flow reduction would only occur in high flow years and thus not add risk to migrating adults.

Each turbine unit at Dworshak Dam requires annual preventative maintenance to maintain operational condition. The annual maintenance period is September 15 through the end of February to coincide with the refill period after summer flow augmentation and before flood control operations begin. Annual maintenance is typically performed one unit at a time and requires the unit to be out of service for 2 to 6 weeks. During the annual maintenance period, adult steelhead from the Clearwater population are present in the tailrace at Dworshak Dam, and mortalities associated with maintenance operations have been documented. Approximately 200 dead steelhead were observed in 2016. Improvements to the protocol have reduced mortality to less than 10 fish per year from 2017 through 2019. Renholds et al. (2019) provide documentation on the mechanism for the mortality events and investigate simple but effective solutions for physical screening systems that if implemented, would be expected to prevent mortality in the future. Future mortality using the updated Fish Passage Plan protocol is expected to be similar to the levels observed from 2017 to 2019 of 0 to 10 fish per year.

CRS-related mortality of downstream migrating kelts (SR, UCR, MCR, and LCR steelhead) is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 40.2 and 44.8 percent of SRB steelhead kelts survived from the Lower Granite forebay to the Lower Columbia River (RM 156) and the Bonneville Dam face (RM 234), respectively, and only 60.4 and 67.3 percent survived from the McNary forebay to the lower Columbia River (RM 156) and Bonneville dam face, respectively. It is important to note that in this study, only fair and good condition kelts were selected for tagging, and these survival rates cannot be applied to poor condition kelts. In a similar study conducted by Harnish et al. (2014), the survival of steelhead kelts through the four Snake River dams averaged 77 percent in 2012 and 49 percent in 2013.

Based on this limited information, the best estimate for mortality of downstream migrating kelts is up to 60 percent of migrating kelts arriving at Lower Granite Dam. These data represent total mortality of outmigrating SRB steelhead kelts and do not distinguish between mortality caused by effects of the CRS operations and other factors. Estimates of "natural" mortality rates for these fish are not available but are thought to be high, as they have typically gone many months without feeding while expending considerable energy migrating and spawning.

Under most conditions, the best operating range for turbines is within 1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE 2020). These short-duration events could slightly reduce turbine unit survival for adult salmonids passing through the turbine units, but the number of adults affected should be extremely low because of the limited time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure and improve ladder attraction conditions for adult SR steelhead, but would also slightly reduce turbine unit survival for adult salmonids passing through the turbine units. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units.

Based on analysis of the past 10 years (USACE 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams from April through June. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. Overall adult survival rates of SR steelhead between Bonneville Dam and Lower Granite Dam should not be measurably reduced at the population, MPG, or DPS level as a result of the proposed turbine unit operations above 1 percent peak efficiency range, because the great majority of these fish migrate outside the April to June period of time when this operation is expected to occur. Kelts and early migrating or overwintering adult steelhead could potentially be exposed to these operations if they were to fall back through a unit when these operations are occurring, but these instances should be very rare and any negative effects should be extremely minimal.

2.3.3.1.5 Juvenile Migration/Survival

The Action Agencies propose to continue to provide fish passage spill (conventional and surface passage), operate juvenile bypass systems, and implement other operations (e.g., ice and trash sluiceways, Bonneville corner collector, etc.) for juvenile passage at the eight lower Snake and lower Columbia River dams. Surface passage structures and juvenile bypass systems exist at all four of the lower Snake River dams, and surface passage structures exist at each of the four lower Columbia dams, and three of them have juvenile bypass systems. The Dalles Dam does not have a juvenile bypass system because of low powerhouse passage rates. Increased spill levels resulting from the flexible spring spill operations are expected to have little negative effect on tailrace conditions at Bonneville, The Dalles, McNary, and Ice Harbor Dams, but could cause eddies to form at other dams under low to moderate flow conditions. The latter would likely increase the exposure to predators of juvenile SR steelhead passing through the spillway, thereby reducing spillway survival by a small, but unknown, amount. Increased spill levels at the other dams (excepting The Dalles Dam which will continue spilling at 40 percent) would generally be expected to slightly increase direct dam passage survival rates of inriver migrating smolts as spillway survival rates generally exceed those in the juvenile bypass systems or through the turbine unites. Overall, the survival of inriver migrating juvenile SRB steelhead from all populations and MPGs should increase slightly as a result of implementing the flexible spring spill levels at each of the eight mainstem dams.[112] Increases in downstream migration survival are expected to increase population productivity by delivering more smolts to the ocean, resulting in more adults returning.

The proposed operations at Libby Dam, Hungry Horse Dam, Grand Coulee Dam, and Dworshak Dam will alter flows by less than 2 percent during the spring migration period. This would be expected to result in very small increases in travel times in April and May, and small decreases in travel times in June, but should not measurably affect juvenile survival. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). For SR steelhead smolts, the flexible spill operation (up to 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. Smolts typically migrate at depths that effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020). Data from all fish sampled from 1996 through 2019 in the CRS Gas Bubble Trauma Monitoring Program indicate that signs of GBT were almost non-existent below 120 percent TDG, increased slightly between 121 and 125 percent TDG, and then increased in both incidence and severity when TDG levels exceeded 125 percent (FPC 2019). Thus, the proposed flexible spill operation would likely

[112] Summer spill levels at the Snake River and lower Columbia River dams will be reduced in late August. However, juvenile SRB steelhead migrate to below Bonneville Dam primarily in April and May and therefore will not be affected by the proposed changes in summer spill operations.

result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable based on reach survival studies) increase in mortality of juvenile SR steelhead.

The Action Agencies propose a change in pool elevation in John Day Reservoir starting April 10 and ending sometime between June 1 and June 15 to reduce predation associated with the Blalocks Island tern colony (see discussion below). Increasing the elevation of John Day Reservoir is likely to increase downstream travel time for juveniles because an increase in surface area with a given river flow will slow down the water and the fish migrating through it. However, the net effect of the John Day Reservoir and flexible spill operations, based on COMPASS modeling for SR Steelhead (see Section 2.7.3.1.5), is likely to be a small reduction in travel time which should benefit juvenile steelhead migrating through this reach.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14. The increase in operating range by itself will reduce travel time slightly for SR steelhead juveniles, however, the net effect of the 1.5 foot operating range and flexible spill operations, based on COMPASS modeling for SR Steelhead (see Section 2.7.3.1.5), is likely to be a small reduction in travel time which should benefit juvenile steelhead migrating through this reach.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. Because SR steelhead juveniles primarily migrate during the spring, they will not be affected by a reduction in summer spill in late August.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. These operations will result in no flow past the projects in the Snake River during these periods. Few to no steelhead juveniles are expected to migrate through the lower Snake River during this period, so this operation will have extremely minimal to no effect on juvenile migration timing or survival.

As described above (see Section 2.3.3.1.4), under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, but the number of juveniles affected should be extremely low because of the low expected frequency of this operation, and expected number of juveniles passing through turbines during flexible spill.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure, would slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, and would slightly increase powerhouse passage rates of juvenile SR steelhead. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units and increase powerhouse passage rates.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams from April through June. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of SR steelhead between Bonneville Dam and Lower Granite Dam, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population, MPG, or DPS level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

2.3.3.1.6 Transportation

SRB steelhead smolts will continue to be collected for transport at the three Snake River collector projects. The increased spill will result in more juvenile fish going over the spillway and fewer fish being transported on a given date. This effect will be especially pronounced in low to medium flow years. Should TIR ratios continue to demonstrate an overall benefit of transport to SRB steelhead, the expected decrease in transport rates resulting from increased spill at the three collector projects would, on average, result in a slight reduction in adult returns.

The decrease in the daily proportion of fish collected due to higher spill would be countered by an increase in the proportion of the juvenile run that is collected if transport is started earlier. SRB steelhead smolts begin arriving at the collector projects in early April. Starting transport in April, as was done in the past three years (start date of April 23 in 2018 and April 24 in 2019 and 2020), results in higher numbers of natural-origin and hatchery spring/summer Chinook salmon smolts transported. The Action Agencies propose a target start date for transportation of April 24, but also propose that the start date may be adaptively managed to begin as early as April 15, or as late as May 1. The earlier start of transport in 2018 to 2020 will provide new data to inform an analysis of the benefit of transport in late April. If a survival benefit is observed for juvenile transport during late April, the Action Agencies have proposed beginning transport even earlier, on April 15. From 2010 to 2019, an average of 50 percent of SRB steelhead had arrived at Lower Granite Dam by April 15, and so an April 15 start date would substantially increase the proportion of smolts that are transported (and decrease the proportion of fish bypassed back the river), which could improve overall juvenile survival and adult return rates. In the future, SRB steelhead may outmigrate even earlier in response to climate change, and in this case adaptively managing to start transport earlier could similarly improve juvenile survival and adult return rates.

The proposed cessation of transport from June 21 to August 15 will reduce the collection and transportation of the latest-migrating SRB steelhead smolts. From 2010 to 2019, on average, 95 percent of SRB steelhead had arrived at Lower Granite Dam by May 25, but a few smolts continue to migrate in the Lower Snake River in June and July. These late-migrating smolts generally benefit from transport. However, their numbers are so few that the effect of stopping transport from June 21 to August 15 would be minimal for SRB steelhead. The decision on when to stop and then restart juvenile fish transport would remain subject to the TMT and FPOM decision processes and the dates could be changed, for example if smolt outmigration timing shifts later in a given year and ceasing transport on June 21 is determined to be detrimental.

COMPASS Model Results

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effects of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT-tag (detection efficiencies and project and reach survival estimates) and acoustic-tag (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model.

For juvenile SRB steelhead, COMPASS estimates that under the proposed flexible spring spill operation (up to 125 percent TDG) and increased pool elevations at the Snake River projects and John Day Dam:

- Average juvenile travel time from Lower Granite tailrace to Bonneville Dam tailrace is 15.8 days.
- Average juvenile survival from the head of Lower Granite Reservoir to Bonneville Dam tailrace is 42.6 percent.
- Average proportion of juveniles approaching Lower Granite Dam that are destined for transport is 26.5 percent.
- Average number of spill passage events (the inverse of the CSS's PITPH metric) is 6.9 for the eight dams traversed (Lower Granite to Bonneville).

The CSS hypothesizes that flexible spring spill would reduce latent mortality by reducing the number of powerhouse encounters. The CSS estimates that the 125 percent TDG flexible spill operation will increase adult returns (SARs) by 28 percent (USACE et al. 2020). However, another possible explanation for reduced return probabilities of bypassed fish is that fish that are smaller or in poorer condition enter bypass systems at higher rates than fish that are larger or in better condition (Zabel et al. 2005, ISAB 2012, Hostetter et al. 2015, Faulkner et al. 2019), and smaller fish and fish in poorer condition also have lower return probability (Ward and Slaney 1988, Zabel and Williams 2002, Evans et al. 2014). This suggests that the apparent effects of juvenile bypasses on juvenile survival and adult return probability are due, at least in part, to the correlation between bypass probability and fish size and condition, and not due to bypass itself. Thus, increasing spill levels will increase incrementally the proportion of fish passed via spill and will reduce travel times. This could improve direct survival rates for juveniles, assuming spillway passage survival is not substantially reduced as a result of poor egress and tailrace conditions. However, increasing spill levels might not increase adult returns to the extent hypothesized by the CSS; since higher spill levels can result in degraded tailrace conditions, juvenile survival could be lower than COMPASS predicts due to extended time in the tailrace and increased potential for predation at some projects.

These COMPASS estimates of survival rates and travel times do not estimate the magnitude of effects solely attributable to the operation of the CRS projects. We expect that some of the mortality and delay in travel times is attributable to the existence of the eight mainstem dams as opposed to operational or configurational choices. In addition, some sources of mortality, such as predation, are captured in the COMPASS estimates but would exist at some level regardless of the proposed action. The mortality of just more than half the juvenile SRB steelhead from Lower Granite Reservoir to Bonneville Dam estimated from the models is therefore due to a combination of these factors. Accordingly, we view the effects of the hydrosystem action on juvenile mortality and travel times as being less than the COMPASS estimates, but to an unknown degree.

2.3.3.1.7 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to SRB steelhead as they migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty about predicting the availability of habitat restoration actions into the future and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework will support the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management of the restoration program. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and will be initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the action effectiveness monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program either will confirm that these floodplain reconnections are enhancing conditions for yearling salmonids, such as SRB steelhead as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action and beyond.

With all of these program elements in place (rolling 5-year reviews, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change considerations and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management, which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the influx of insect and amphipod prey to the mainstem migration corridor for juvenile SRB steelhead. It is also reasonably certain that these benefits will increase as habitat quality matures, contributing to increased abundance, productivity, and life-history diversity[113] of all SRB steelhead populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.3.3.1.8 Tributary Habitat

For the SRB steelhead DPS, the Action Agencies will implement tributary habitat improvements to achieve the MPG-level metrics outlined in Table 2.3-13. These habitat improvement actions will be implemented in four of the five MPGs: Grande Ronde, Clearwater River, Salmon River,

[113] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile steelhead opportunities to move into wetland habitats for food and refuge from predators. In addition the large numbers of prey that move out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increase prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the SRB steelhead DPS.

and Lower Snake River.[114] Actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations, and will accomplish specific metrics defined for each MPG (BPA et al. 2020).

Table 2.3-13. Proposed tributary habitat metrics (2021–2036) for major population groups in the SRB Steelhead DPS (BPA et al. 2020).

Snake River Steelhead DPS Major Population Group	Habitat Improvement Actions[1]					
	Flow Protected (cfs)	Flow Enhanced (acre-feet)	Entrainment Screening (# screens)	Habitat Access (miles)	Stream Complexity (miles)	Riparian Habitat Improved (acres)
Grande Ronde	178	15,509	0	96	30	1069
Clearwater River	0	0	0	31	16	1258
Salmon River	170	14,309	38	54	19	979
Lower Snake	0	0	0	6	29	349
Snake River Basin Steelhead DPS Totals	348	29,818	38	187	94	3,655

[1]The habitat actions that produce these metrics will be completed or in process by the end of 2036.

To develop these metrics, the Action Agencies reviewed implementation under the 2008 and 2019 biological opinions and developed metrics for the proposed action assuming a consistent level of effort for tributary habitat implementation. In addition, the Action Agencies have committed to continuing to improve the strategic implementation of the program; to continue implementing the program with input from the THSC that was convened under the 2019 biological opinion; to convene a TTT to provide input to program implementation; to report on implementation using metrics that will allow NMFS to evaluate implementation of the program; to undertake comprehensive program reviews every 5 years to evaluate how to enhance benefits from the program; and to conduct RME to assess tributary habitat conditions, limiting factors, and action effectiveness, and to inform our understanding of critical uncertainties (BPA et al. 2020).

As part of the adaptive management program, the Action Agencies, with input from the THSC and TTT, will reevaluate implementation at 5-year intervals (see Appendix D of BPA et al. 2020). The proposed metrics after the first 5-year period may be adaptively managed to optimize fish benefits based on understanding of species status and population priorities, limiting factors, what actions will provide the greatest benefits, implementation considerations, etc.

[114] The focus on implementation in these MPGs is generally consistent with past implementation of the Action Agencies' tributary habitat program.

For an overview of how NMFS analyzed the effects of tributary habitat improvement actions for this opinion, see Appendix A. In brief, we reviewed and re-affirmed the strong technical foundation for the tributary habitat program (i.e., that strategically implementing actions to alleviate the factors that limit the function of tributary habitat will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead). We evaluated new RME information and found that it also supported the foundation and goals of the program. We determined that the methods we were using to evaluate the effects of tributary habitat actions were based on best available science, as described in Appendix A. For steelhead, we evaluated the effects of those actions qualitatively within the context of our understanding of limiting factors, the effects of the types of habitat improvement actions being proposed, population extinction risk, habitat improvement potential, and our ESA recovery plan framework. Life-cycle models for SRB steelhead were not available for this analysis. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered certainty of implementation and effects, as well as the strategic framework within which the Action Agencies were committing to implement the program. In addition, we considered the adequacy of the RME and adaptive management framework that is proposed to guide and refine implementation of the habitat improvement actions and inform our understanding of their effects, and the adequacy of the proposed reporting on actions implemented.

Our assessments are described below by MPG, followed by a DPS-level summary.

Salmon River MPG

For the Salmon River MPG, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, reduce entrainment by screening water diversions, improve habitat access, and improve riparian habitat. Limiting factors in this MPG include reduced flows, passage barriers, unscreened irrigation diversions, and reduced riparian function (see Section 2.3.2.4), these actions would be targeted toward addressing identified limiting factors.

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.3-14. The positive changes noted in the table may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

Table 2.3-14. Effects and timing of effects of proposed tributary habitat improvement actions for SRB steelhead.

Action Type	Effects of action and timing of effects
Flow protection and enhancement	Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017a). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Sabaton et al. 2008; Roni et al. 2014). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and the success of these projects (Roni et al. 2008). For example, ongoing studies in the Lemhi River show increased spawner and juvenile abundance of both Chinook salmon and steelhead following enhancement of instream flows in tributaries (Uthe et al. 2017; Appendix A of Griswold and Phillips 2018). The effects of flow augmentation on habitat conditions depend on the amount of flow within the channel and how much water is added. Augmented flow in dewatered channels or streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).
Entrainment	Diversion of water from rivers can negatively affect salmon and steelhead populations. For example, open, unmodified water diversions can act as a source of injury or mortality to resident or migratory fishes from entrainment and impingement, and can cause habitat degradation and fragmentation. Fish-protection devices, such as exclusion screens, can physically or behaviorally deter fish from approaching or being entrained into water diversions. Most monitoring of screening projects is compliance monitoring rather than effectiveness monitoring, with a focus on whether installation or upgrading screens has reduced entrainment of fish into irrigation or water withdrawal systems. In one evaluation, however, Walters et al. (2012) conducted modeling that indicated that an extensive program to install screens at irrigation diversions in the Lemhi River had potentially significantly reduced mortality of out-migrating Chinook salmon smolts. Screening irrigation or water withdrawal systems and reconnecting spawning and rearing streams often provide immediate and important survival and carrying capacity benefits (Hillman et al. 2016).
Improved habitat access	Impaired fish passage can prevent adults from accessing upstream spawning habitat and impede juvenile fish migration. In addition, structures that impede fish passage can disrupt habitat-forming processes related to flow, sediment transport, and large wood (NMFS 2013a, 2017a). Improving fish passage through actions that replace, improve, or remove culverts, dams, and other migration barriers, or that provide fish passage structures, can provide access to previously inaccessible spawning and rearing habitat. In addition, removing barriers can enhance habitat-forming processes related to flow, sediment transport, and movement of large wood and contribute to improvements in stream morphology, substrate, connectivity, stream flow, and stream temperature (NMFS 2013a, Hillman et al. 2016). Studies evaluating the effectiveness of projects that have removed impassable culverts/dams, or have installed fish passage structures in North America and elsewhere, including in the Columbia River basin, have consistently shown rapid colonization by fishes; some studies have also documented the physical impacts of barrier removal on sediment and channel changes (Hillman et al. 2016). The rate at which salmon and trout recolonize habitats following barrier removal is highly dependent on the amount and quality of habitat upstream of the barrier and the size of

Action Type	Effects of action and timing of effects
	the downstream or nearby source population (number of salmon or trout returning that could colonize) (Hillman et al. 2016).
Improved stream complexity	Stream complexity created by large wood, boulders, coarse substrate, undercut banks, and overhanging vegetation (in concert with adequate flow regimes and other habitat-forming processes) is an essential feature of productive salmon habitat, providing the features needed for adequate spawning and rearing. Functioning floodplains and side-channels with hydrologic connectivity are also key features of productive salmon habitat because they provide rearing, resting, and refuge habitat; increase availability of prey; and enhance other stream and watershed processes (NMFS 2013a, 2017a). Habitat improvement actions commonly implemented to enhance stream complexity include placement of large wood, boulders, and cover structures; gravel addition; floodplain reconnection; side channel and pond construction and reconnection; levee removal and setback; channel re-meandering; and, more recently, the construction of beaver enhancement structures (Roni et al. 2014, Hillman et al. 2016). These actions can be expected to aid in reestablishment of hydrologic regimes, increase availability of rearing habitat, improve access to rearing habitat, increase the hydrologic capacity of side channels, increase channel diversity and complexity, provide resting areas for salmonids, provide flood water attenuation, and enhance native plant communities (NMFS 2013a). The placement of instream structures includes a wide variety of actions that can affect many different habitat factors, so salmonid responses documented in the literature are quite diverse, ranging from small negative responses to large increases in abundance, growth, and survival. Most studies of this type of actions indicate a positive response (increased abundance and density) for salmonids. The lack of response or decrease in abundance identified in some studies was often because the projects did not address upstream watershed processes (e.g., sediment, water quality, etc.), the actions did not address the factors limiting fish, the duration of monitoring was too short to demonstrate a positive effect, or the treatments resulted in little change in physical habitat. Salmonids have also been shown to respond rapidly to reconnected or constructed floodplains, side channels, and wetlands. These habitats provide critical rearing habitat for juvenile Chinook, coho, and steelhead. Studies indicate that these actions increase salmonid abundance, individual growth rates, overwinter survival, and smolt production (Hillman et al. 2016). While benefits of actions to improve stream complexity may be rapid in terms of fish occupying restored habitats, they also will continue to accrue over some time as habitat continues to respond.
Riparian Habitat Improvement	Riparian vegetation provides numerous functions including shading, stabilizing streambanks, controlling sediments, contributing large wood, and regulating the flow of nutrients. Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014, Hillman et al. 2016; NMFS 2017a). Benefits of riparian planning actions take more than 50 years to fully accrue, although some benefits begin to accrue after 5 to 15 years (Justice et al. 2017, Pess and Jordan, eds. 2019). Few studies have examined the response of instream habitat or fish to riparian planting or thinning, in part because of the long lag time between tree growth and any change in channel conditions or delivery of large wood. However, a retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and instream anadromous fish habitat at revegetated sites. Modeling work in the Grande Ronde River indicates that riparian enhancement action should reduce water temperatures and increase juvenile's salmonid abundance up to 377 percent in the Upper Grande Ronde subbasin and 61 percent in Catherine Creek (McCullough et al. 2016). Justice et al. (2017) utilized a stream temperature model to explore potential benefits of channel and riparian restoration on

Action Type	Effects of action and timing of effects
	stream temperatures in the Upper Grande Ronde River and Catherine Creek Basins in Oregon. They focused on streams that had been degraded by intensive land use leading to reduced riparian vegetation and widened channels and concluded that restoration of such streams could more than make up for expected increase in summer stream temperature through 2080. Studies of fish response to livestock exclusion projects have shown variable results. Some have shown increases in salmonid abundance while others have shown no response. Those showing no response were linked to short duration of monitoring, small size of enclosures, and upstream habitat processes that limited habitat conditions in the project area (Hillman et al. 2016).

Potential for improvement in habitat productivity varies among populations in this MPG. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced (Appendix A; also see, e.g., Hillman et al. 2016, Pess and Jordan, eds. 2019).[115]

The Action Agencies have well-developed partnerships with local implementing groups for this MPG. Habitat improvement actions within this MPG are implemented primarily through the Upper Salmon Basin Watershed Program, which includes staff from state, Federal, and local natural resource management agencies; more than 75 ranchers in the upper Salmon River basin; private interest groups; and others. This group has created an effective process for working together, providing technical reviews of proposed projects and working with interested parties to accomplish conservation on the ground. It has a strong record of implementing projects that have made contributions to salmon recovery (NMFS 2017d). In collaboration with these local partners, the Action Agencies have used a variety of tools, including the Screening and Habitat Improvement Prioritization for the Upper Salmon Subbasin, to prioritize and select projects. This team also has relied on guiding documents and information, such as the ESA recovery plan

[115] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. The Action Agencies indicated they would likely focus implementation of tributary habitat actions on the SR spring/summer Chinook salmon populations identified as priority populations in the 2008 biological opinion (BPA et al. 2020). These actions will also have benefits for the overlapping SRB steelhead populations. To achieve recovery under the ESA recovery plan, the South Fork Salmon, Lower Middle Fork Salmon, Upper Middle Fork Salmon, and Chamberlain Creek, populations must achieve viable or highly viable status, and the Little Salmon, Secesh, Panther Creek, North Fork Salmon, Lemhi, Pahsimeroi, East Fork Salmon, and Upper Salmon River populations must achieve viable or maintained status (NMFS 2017a). NMFS' focal population concept (Cooney et al. 2020a) will further inform decisions about which populations have the highest potential to benefit MPG status in the near term from directed habitat actions. NMFS intends to work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent they are not currently aligned.

(NMFS 2017a), tributary assessments, and additional technical analysis to sequence actions and areas to implement habitat actions in priority watersheds within this MPG. This on-the-ground infrastructure, combined with the Action Agencies' commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

Grande Ronde River MPG

For the Grande Ronde MPG, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, improve habitat access, improve stream complexity, and improve riparian habitat. Limiting factors in this MPG include reduced flows, loss of habitat complexity, reduced riparian function, and passage barriers (see Section 2.3.2.4). The actions would be targeted toward addressing these identified limiting factors.

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.3-14. The positive changes noted in Table 2.3-13 may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

There is high potential for improvement in habitat productivity in most populations in this MPG. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016, ISAB 2018, Pess and Jordan eds. 2019).[116]

The Action Agencies have well-developed partnerships with local implementing groups in this area. To help guide restoration priorities in the severely degraded Catherine Creek and Grande Ronde subbasins, the Action Agencies have worked with local partners since 2011 to develop, implement, and adaptively manage the Atlas process (described above in Section 2.3.2.4), a systematic approach to identify and prioritize the actions that would be most likely to improve habitat. The Atlas framework has resulted in implementation of habitat improvement actions that target high-priority reaches for the Upper Grande Ronde and Catherine Creek populations (NMFS 2014a, BPA et al. 2016, 2020). This on-the-ground infrastructure, combined with the Action Agencies' commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

Lower Snake River MPG

For the Lower Snake River MPG, the Action Agencies have committed to continuing to implement actions to improve habitat access, improve stream complexity, and improve riparian habitat. Limiting factors in this MPG include reduced flows, loss of habitat complexity, and reduced riparian function (see Section 2.3.2.4). The actions would be targeted toward addressing these identified limiting factors.

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.3-14. The positive changes noted in Table 2.3-13 may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we

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[116] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. The Action Agencies indicated they would likely focus implementation of tributary habitat actions on the SR spring/summer Chinook salmon populations identified as priority populations in the 2008 biological opinion (BPA et al. 2020). These actions will also have benefits for the overlapping SRB steelhead populations. To achieve recovery under the ESA recovery plan, the Lower Grande Ronde River and Wallowa River populations must achieve viable or maintained status, the Upper Grande Ronde population must achieve viable or highly viable status, and Joseph Creek must achieve highly viable, viable, or maintained status (NMFS 2017a). NMFS' focal population concept (Cooney et al. 2020a) will further inform decisions about which populations have the highest potential to benefit MPG status in the near term from directed habitat actions. NMFS intends to work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent they are not currently aligned.

discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

There is potential for additional improvement in habitat productivity in both populations in this MPG. Actions implemented to ameliorate limiting factors for either population would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016, Pess and Jordan, eds. 2019).[117]

The Action Agencies have well-developed partnerships in this area with local implementing partners, including the Snake River Salmon Recovery Board, the CTUIR, the U.S. Forest Service, and the WDFW. A regional technical team, composed of fish biologists and other natural resource specialists with extensive field experience and knowledge of local watershed conditions, reviews actions before implementation (Appendix A of BPA et al. 2013). Specific reach-scale actions carried out under the Tucannon River Programmatic Habitat Project, funded by BPA, will be identified and prioritized based on detailed assessment information and taking into account key elements from the watershed restoration framework recommended by Beechie et al. 2010. Since 2012, the Action Agencies have used a geomorphic assessment to strengthen the technical understanding of physical conditions and geomorphic processes in the basin, and to identify and prioritize habitat improvement opportunities. This assessment characterized channel and floodplain conditions, channel confinement, the historical channel area, and the source, magnitude, and distribution of hydrologic and sediment inputs through the basin. This information was used to delineate reaches throughout the river that offer potential improvement opportunities. This on-the-ground infrastructure, combined with the Action Agencies

[117] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. The Action Agencies indicated they would likely focus implementation of tributary habitat actions on the SR spring/summer Chinook salmon populations identified as priority populations in the 2008 biological opinion (BPA et al. 2020). These actions will also have benefits for the overlapping SRB steelhead populations. To achieve recovery under the ESA recovery plan, both the Tucannon and Asotin populations must achieve at least viable status and one must achieve highly viable status (NMFS 2017a). NMFS' focal population concept (Cooney et al. 2020a) will further inform decisions about which populations have the highest potential to benefit MPG status in the near term from directed habitat actions. NMFS intends to work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent they are not currently aligned.

commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that actions will be implemented strategically.

Clearwater River MPG

For the Clearwater River MPG, the Action Agencies have committed to continuing to implement actions to improve habitat access, stream complexity, and riparian habitat. Limiting factors in this MPG include passage obstructions, reduced stream complexity, and reduced riparian function (see Section 2.3.2.4), so these actions will be targeted toward addressing identified limiting factors.

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.3-14. The positive changes noted in the table may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

There is potential for improvement in habitat productivity in all populations in this MPG. The Action Agencies have committed that actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where actions are implemented consistent with ESA recovery plan population priorities and the best available science (e.g., watershed assessments) and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale, benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016, ISAB 2018, Pess and Jordan, eds. 2019).[118]

[118] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. The Action Agencies indicated they would likely focus implementation of tributary habitat actions on the SR spring/summer Chinook salmon populations identified as priority populations in the 2008 biological opinion (BPA et al. 2020). These actions will also have benefits for the overlapping SRB steelhead populations. For this MPG, the Action Agencies implemented actions to benefit all five extant populations, although their efforts were most intensive for the Lochsa, Lolo Creek, and Clearwater populations. Of the five extant populations in this MPG, the

The Action Agencies have well-developed relationships with state, Federal, and tribal implementing partners in the Clearwater River MPG. For example, the Action Agencies have been working with their partners in the Lochsa River subbasin to develop an Atlas project for the Lochsa River subbasin. As described above, the Atlas framework has resulted in the implementation of habitat improvement projects that target high-priority reaches for steelhead. This on-the-ground infrastructure, combined with the Action Agencies commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

Imnaha River MPG

The Action Agencies have not proposed tributary habitat improvement actions for implementation in this MPG.

Summary of Effects to Tributary Habitat

Implementation of the proposed tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will provide near-term and long-term benefits to the targeted populations by improving their tributary habitats in the manner and timeframes outlined in Table 2.3-13, above. These benefits will accrue in four of the five MPGs in this DPS (the Grande Ronde River, Clearwater River, Salmon River, and Lower Snake River MPGs) (i.e., the MPGs where the Action Agencies have proposed to implement actions).

These improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations. In addition, certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change (Beechie et al. 2013, McCullough et al. 2016, Justice et al. 2017). Further, Crozier et al. (2019) looked at methods of increasing climate resilience for Pacific salmon and steelhead and concluded that reducing any anthropogenic stressor could improve response to climate change by improving the overall status of an ESU or DPS (in terms of abundance, productivity, spatial structure, and diversity), thereby making the ESU or DPS more resilient and less vulnerable to stochastic extinction. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to

recovery plan calls for the Lower Mainstem Clearwater, Lolo Creek, and Lochsa River populations to achieve viable or highly viable status, and for the South Fork Clearwater and Selway River populations to achieve viable or maintained status (NMFS 2017a). NMFS' focal population concept (Cooney et al. 2020a) will inform decisions about which populations have the highest potential to benefit MPG status in the near term from directed habitat actions. NMFS intends to work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent they are not currently aligned.

respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action.

2.3.3.1.9 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail in the site-specific biological opinions referenced therein (see Section 2.3.2.2). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.3.3.1.10 Predation Management

Avian Predators

Avian Predators in the Lower Columbia River Estuary

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions are likely to continue current levels of predation at these colonies, which, in the case of Caspian terns, is an average annual reduction of 14.6 percent from the pre-colony management period. However, ocean conditions, including compensatory effects such as the number and behavior of predators and competition for prey, will determine whether this reduction in tern predation influences adult returns. Although there appears to have been a small to moderate decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 7.2 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, cormorant predation in the estuary may be an increasingly important source of mortality for SRB steelhead.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none have been proposed at this time.

Avian Predators in the Hydrosystem Reach

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia River and Snake River dams. At each dam, bird numbers will continue to be monitored, birds foraging in dam tailraces will be hazed (including, in some circumstances, lethal reinforcement), and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas and near juvenile bypass outfall areas, will also continue. If proven biologically and cost effective, the Corps will deploy laser systems to haze birds foraging near bypass outfalls. Upgrades to existing systems, including bird wires at McNary Dam, will be coordinated through the FPOM and included in the annual Fish Passage Plan. We expect that these measures will continue to reduce predation on juvenile SRB steelhead, although Zorich et al. (2012) were unable to quantify the amount of protection.

The Action Agencies propose to continue to address Caspian tern predation on lands that they manage on the interior Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. These measures are likely to preclude use of Crescent Island by Caspian terns during the period of the proposed action. Reclamation will continue passive and active dissuasion efforts for Caspian terns on Goose Island. They have coordinated the timing and duration of the proposed work with USFWS to ensure it will be effective in maintaining the management objectives of fewer than 40 breeding pairs at this site, consistent with the IAPMP. This ongoing suite of colony management actions is likely to continue current levels of predation by terns in the interior Columbia River basin, which is a small improvement compared to the pre-colony management period.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the hydrosystem reach are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

John Day Reservoir—Spring Operations to Reduce Predation Rates by Caspian Terns

The Action Agencies propose to hold the elevation of John Day Reservoir at 264.5 to 266.5 feet from April 10 to June 1 or no later than June 15 each year, or as feasible based on river flows, to inundate bare sand habitat and deter Caspian terns from nesting in the Blalock Islands Complex. Because foraging effort and predation rates increase once chicks hatch, the Action Agencies will begin to increase the reservoir elevation before Caspian terns initiate nesting (i.e., operations may begin earlier than April 10). The Action Agencies will consider bird observations along with the run timing of juvenile steelhead to determine the dates each year. At the conclusion of this operation, the draft to operating range (262.5 to 264.5 feet) will be completed within 4 days. In general, 95 percent of the juvenile steelhead migration passes John Day Dam by June 1 each year (DART 2020m).

The timing of this operation is based on the expectation that Caspian terns will begin colonizing exposed habitat and start courtship and nest building within days to weeks of returning the reservoir to the 262.5 to 264.5-foot range. In general, chicks hatch about 27 days after eggs are laid, at which point energetic demands and fish consumption rates increase substantially. Thus, we expect that inundating bare sand habitat until after 95 percent of yearling steelhead pass John Day Dam will reduce predation rates on individuals from the SRB steelhead DPS.

Fish Predators

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. This fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the average number of steelhead, including some SRB steelhead that will be handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy) will be no more than 100 adults (including jacks) and 600 juveniles per year. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams and will conduct test fisheries at additional dam projects on the Snake River, as described in the proposed action (BPA et al. 2020). As the Dam Angling Program evolves and potentially expands, it may help to further reduce predation on SRB steelhead juveniles and improve survival. We estimate that no more than 10 adults and 20 juvenile steelhead, including some from the SRB steelhead DPS, will be caught in the Dam Angling Program per year.

These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including SRB steelhead.

Pinniped Predators

To reduce the number of ESA-listed salmon and steelhead impacted by pinnipeds at fish ladder entrances at Bonneville and The Dalles Dams, the Action Agencies propose to continue to annually install (or leave installed year-round), and improve as needed, sea lion excluder devices at all adult fish ladder entrances at Bonneville Dam. The Corps will continue to annually fund dam-based hazing of pinnipeds observed in the vicinity of fish ladder entrances at Bonneville Dam. Hazing will generally be conducted from March 31 through May 31 and from August 15 through October 31. Hazing efforts will be focused on minimizing the amount of time that individual sea lions spend foraging near fish ladder entrances, but may also include dissuasion in haul-out areas at the dam (BPA et al. 2020).

The Corps will continue to provide the states and tribes with access to Bonneville Dam and the Bonneville Dam boat restricted zone, as appropriate, to support sea lion predation management. The Corps will provide support to fish and wildlife management personnel during sea lion dissuasion and/or removal operations. The Corps will fund dam-based hazing of pinnipeds observed in the vicinity of fish ladder entrances at The Dalles Dam on an ad hoc, as needed basis. Researchers estimate pinnipeds consumed 1.6 percent of the adult steelhead passing Bonneville Dam from July 14 to December 31 in 2018 (Tidwell et al. 2020), which is the best available information on the magnitude of pinniped predation on SRB steelhead at Bonneville Dam. These ongoing measures and addition of fall hazing and dissuasion are expected to maintain or slightly reduce current levels of sea-lion predation on SRB steelhead in the Bonneville Dam tailrace.

2.3.3.1.11 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult SRB steelhead are likely to be present in shallow shoreline areas, an unknown portion of the DPS will continue to be stunned, harmed, or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed, and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this DPS that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[119]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of SRB steelhead will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS.
  - One hatchery and one natural-origin adult will be handled and/or die.
  - One hatchery or one natural-origin adult will die.
  - 43,000 hatchery and 16,400 natural-origin juveniles will be handled.
  - 827 hatchery and 318 natural-origin juveniles will die.

- Activities associated with all other RME programs.
  - 12,700 hatchery and 3,200 natural-origin adults will be handled.
  - 60 hatchery and 15 natural-origin adults will die.
  - 125,000 hatchery and 110,000 natural-origin juveniles will be handled.
  - 1,250 hatchery and 400 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program is expected to affect, on average, up to 21 percent of the natural-origin adult (recent, 5-year average) run (arriving at Lower Granite Dam) and up to 16 percent of naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to less than 1 percent of estimated DPS abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations

[119] Ongoing and future discussions are expected to lead to reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

(including facilities modifications and mitigation actions), the effects of the RME programs on abundance are acceptable and warranted.

2.3.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small improvement to safe passage for inriver juvenile migrants at the eight mainstem dams. Adults migrating during periods of gas cap spill are likely to experience a small reduction in safe passage due to an increased rate of involuntary fallback over the spillway. Implementation will also affect the volume and timing of flow in the Columbia River, which alters habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.3-15.

Table 2.3-15. Effects of the proposed action on the physical and biological features essential for the conservation of the SRB steelhead DPS.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning and rearing sites	The Action Agencies will implement tributary habitat improvements to achieve the MPG-level metrics outlined in Table 2.3-13. These actions are likely to improve water quality (e.g., temperature), water quantity, substrate, floodplain connectivity, forage, and natural cover at the local scale in watersheds with spawning and rearing sites. After the first 5-year period, the proposed metrics may be adaptively managed to optimize fish benefits and the functioning of spawning and rearing sites.
Freshwater migration corridors	*Effects on migration corridor PBFs apply to all populations and MPGs of SRB steelhead except where specified.* Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. The proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not affect the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal mainstem temperature regime in the Snake and Columbia Rivers due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and early summer, when juvenile SRB steelhead are migrating, and warmer temperatures in the summer and fall. Most adults enter the lower Columbia River during summer, so this alteration will continue to adversely affect the functioning of the migration corridor. The Action Agencies will continue to release cold water from Dworshak Dam on the North Fork Clearwater River so that temperatures in the Lower Granite tailrace do not exceed 68°F and will operate fishway cooling pumps at the tops of the adult fishways at Lower Granite and Little Goose Dams to prevent migration delays. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume, which may reduce "cover" in the

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	juvenile migration corridor. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill at the CRS run-of-river projects in the lower Snake and Columbia Rivers. The effect on water quality in terms of an increase in the incidence of GBT is likely to be very small. Increased spill levels resulting from the flexible spring spill operation (to 125 percent TDG) are likely to degrade tailrace conditions at Lower Granite, Little Goose, Lower Monumental, and John Day Dams (obstructions in the juvenile migration corridor), increasing the risk of bird and fish predation under low flow conditions (excessive predation). The flexible spring operation to 125 percent TDG will reduce obstructions in the juvenile migration corridor by a small amount by increasing the likelihood of spillway passage. However, increased spill levels are likely to degrade tailrace conditions at Lower Granite, Little Goose, Lower Monumental, and John Day Dams (obstructions in the migration corridor), increasing the risk of bird and fish predation under low flow conditions. The flexible spring operation to 125 percent TDG will not increase obstructions in the adult migration corridor for most SRB steelhead, which are summer migrants. Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (increase in safe passage). However, by increasing powerhouse flows, it will decrease safe passage for juveniles and adults by a small amount because some will pass downstream or fall back through a turbine unit. The Corps will continue to protect water quality by using best management practices to minimize accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. The potential cessation of power generation at Snake River projects between 2300 and 0500 hours, October 15 to February 28, is likely to create a very small increase in obstructions for adult SRB steelhead because very few actively migrating at night. Juveniles will not be present during this period. Continued small increases in obstructions for adult steelhead during routine outages of fishways or turbine units. Very small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities (e.g., to upgrade turbines at Ice Harbor, McNary, and John Day Dams and for a major repair such as the jetty and retaining wall at Little Goose Dam). Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Long-term effect of turbine upgrades will be reduced obstructions (improved turbine survival). Repairing the jetty at Little Goose Dam will also reduce obstructions for adults at that project. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	adjacent units and providing additional attraction to other passage routes. Continued implementation of the Action Agencies' bird, fish, and pinniped predator management programs will continue recent levels of predation in the juvenile and adult migration corridors.
Estuarine areas	*Effects on migration corridor PBFs apply to all populations and MPGs of SRB steelhead* Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation and side channels. This will increase access to prey, for yearling steelhead that migrate in the mainstem channel without entering floodplain sites. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP will control levels of fish predation (ongoing reduction in levels of predation).

2.3.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.3.1), Environmental Baseline (Section 2.3.2), and Effects of the Action (Section 2.3.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation;

acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to improve conditions for the salmon and steelhead, including SRB steelhead.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include effects associated with human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.3.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.3.3) to the environmental baseline (Section 2.3.2) and the cumulative effects (Section 2.3.4), taking into account the status of the species and critical habitat (Section 2.3.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.3.5.1 Species

The SRB steelhead DPS comprises 24 extant populations in five MPGs. The North Fork Clearwater population (part of the Clearwater River MPG) is extirpated. The most recent status review (NMFS 2016b) noted that, based on aggregate counts of steelhead at Lower Granite Dam, the abundance of both A-Index and B-Index steelhead groups had increased substantially from the previous review. The most recent status review rated two populations as low or very low risk, 18 populations as maintained, and four populations as either maintained or at high risk. More recent adult returns (2014 to 2018) indicate a recent, and substantial, downward trend in the abundance of spawners when compared to the 2009 to 2013 period and from the high adult return year in 2014. The preliminary estimates of abundance for 2019 to 2020 adults are also low. This downturn is associated with a marine heatwave and its lingering effects, which likely contributed to substantially lower ocean survival rates of juvenile steelhead. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants. The ESA recovery plan (NMFS 2017a) identified several limiting factors: tributary habitat degradation, estuarine habitat degradation, hydropower, harvest, hatchery programs, predation, and additional factors (exposure to toxic contaminants and the effects of climate change).

With the exception of the Tucannon River population, which must pass six mainstem dams, SRB steelhead populations must pass eight mainstem dams on the lower Snake and lower Columbia Rivers to reach the ocean and return to their spawning grounds. Conditions for SRB steelhead populations have generally improved in the mainstem Columbia River because of the installation and operation of surface passage routes, 24-hour spill, improved spill patterns, and improvements to the juvenile bypass systems at the mainstem dams. Lower Granite to Bonneville Dam survival rates for hatchery and natural-origin juvenile steelhead vary substantially (42 to 76 percent), but have averaged about 55 percent the past 10 years (2010 and 2019) (Zabel 2019, Widener et al. 2020).

The juvenile survival rates from Lower Granite Dam to Bonneville Dam include all sources of mortality, even those that are not caused by the past or proposed operation and maintenance of the CRS. For instance, regardless of the operational or configurational choices made for the hydrosystem, some predation and other natural mortality of juvenile SR steelhead would occur during their migration. In addition, juvenile survival is influenced by past and present alterations of shoreline habitat, among other stressors, unrelated to the effects of operating the hydrosystem; many of those effects will continue into the future. We are unable to differentiate the proportion of the losses that result from the operation and maintenance of the mainstem dams rather than to the existence of the dams, but we know that the mortality attributable to operations and maintenance is less than the losses captured in the overall survival estimates. As discussed further below, some also hypothesize that passage through juvenile bypass systems and turbines causes latent mortality, which would not be captured in the direct survival estimates.

Juvenile steelhead are transported from Lower Granite, Little Goose, and Lower Monumental Dams. Transportation rates have decreased substantially since about 2007, primarily as a result of later transport start dates (May 1 from 2008 to 2017), earlier migration timing, and higher spill levels. Transport operations began earlier in 2018 (April 23), 2019 (April 24), and 2020 (April 24) to increase the proportion of juveniles transported (decreasing the proportion that would otherwise be bypassed to continue migrating in the river). The benefit of transport (adult returns of transported fish relative to those bypassed back to the river) varies throughout the season, but annual averages have favored transported fish since 2008, except in 2012, when the relative returns of bypassed fish were somewhat higher than that of transported fish. We expect that the proposed earlier transport start dates, and juvenile monitoring associated with the adaptive management program, should ensure that transport will continue to provide benefits to SRB steelhead and be responsive to potential future changes in juvenile migration timing.

Adult survival rates (adjusted to account for reported harvest and typical straying rates), include “natural” mortality as well as any mortality associated with injuries incurred from predators. Adult survival rates for SRB steelhead are relatively high, averaging over 93 percent between Bonneville and McNary dams and 87 percent between Bonneville and Lower Granite Dams. Increased spring spill levels should affect few adults, which primarily migrate in late summer and fall or early spring. For these few adults, although increased spring spill levels are expected to slightly increase adult fallback rates, associated mortalities should be offset by adults falling back through spillbays (which have higher survival rates than juvenile bypass systems or turbine units). A small increase in adult mortalities could occur as a result of adults ascending the ladders but then falling back through the turbines at Snake River dams in August, when spill is reduced. However, these losses would not be expected to substantively affect survival rates. Substantial numbers of adults from the Tucannon River population overshoot Little Goose and Lower Granite dams and then “fall back” during the fall and spring in order to ascend the Tucannon River when temperatures are more favorable. A study to assess the efficacy of operating a surface passage route to provide safe and effective downstream passage for Middle Columbia River steelhead at McNary Dam began in the fall of 2019. This study is expected to identify operational measures that could be used at McNary and other dams to provide effective downstream passage for adult steelhead that overshoot their natal streams.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Overall, scheduled maintenance activities are expected to continue to negatively affect small numbers of adult SRB steelhead annually. A few adults will die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. Very few juveniles are likely to be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled. Non-routine and unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the inseason adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative spill or turbine unit priorities) will likely minimize these impacts.

The proposed increase in spring spill levels utilizes a program of voluntary fish passage spill with the highest spill volumes ever implemented. This will increase juvenile exposure to higher TDG levels; however, it is unlikely that spilling up to 125 percent TDG for 16 hours per day at most mainstem dams[120] will result in substantial, negative impacts to juvenile survival (or adult passage, for those few adults present) because there are sufficient data and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). The proposed 125 percent flexible spill operation could improve direct juvenile survival rates through the four lower Snake and four lower Columbia River mainstem projects (with the possible exception of Bonneville Dam, where survival rates could potentially decrease slightly, and at The Dalles Dam, which will maintain spill levels of 40 percent). The potential for negative effects from increased TDG may be greater for juvenile steelhead than for other species because they tend to migrate higher in the water column; however they typically occur deeper than 1 to 2 meters from the surface so depth compensation would still ameliorate effects of high TDG. NMFS' COMPASS model predicts that inriver survival rates will increase slightly as a result of increased spring spill levels associated with the flexible spill operation compared to the No Action Alternative (USACE et al. 2020). The CSS model predicts more substantial increases, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillways) will increase adult returns of the Snake River populations by about 28 percent. If these predictions are realized, they would represent a substantial near-term improvement in productivity and abundance for SRB steelhead and, over time, would reduce the severity of expected declines in abundance and productivity caused by warming climate and deteriorating ocean conditions.

Tributary habitat conditions for steelhead vary significantly throughout the Snake River basin, depending on historical and current land use activities and natural conditions. Generally, the ability of tributary habitats in the Snake River basin to support the viability of this DPS is limited by one or more of the following factors: 1) impaired fish passage, 2) reduced stream complexity and channel structure, 3) excess fine sediment, 4) elevated summer water temperature, 5) diminished stream flow during critical periods, 6) reduced floodplain connectivity and function, and 7) degraded riparian condition.

Many habitat improvement actions have been implemented throughout the Snake River basin. These actions have been targeted toward addressing limiting factors and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. NMFS has determined that these actions have improved, and will continue to improve, habitat in the targeted populations as these projects mature, and that fish population abundance, productivity, spatial structure, and diversity will respond positively. The benefits of some of these actions will continue to accrue over several decades. At the same time, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

While tributary habitat conditions are likely improving in some areas as a result of habitat improvement actions and improved land use practices, in general they are still degraded and

[120] Except at John Day Dam, The Dalles, and Bonneville Dam, where proposed spill operations are limited to 120 percent TDG, 40 percent spill, and 150 kcfs, respectively.

continue to negatively affect SRB steelhead abundance, productivity, spatial structure, and diversity. The potential exists to further improve tributary habitat capacity and productivity in this DPS, although the potential varies by population. Additional tributary habitat improvements are needed to achieve recovery goals.

Implementation of the tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will provide additional near-term and long-term benefits to the targeted populations by improving tributary habitat in the manner and timeframes outlined in Table 2.3-13, above. In addition, certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change (Beechie et al. 2013, McCullough et al. 2016, Justice et al. 2017). Crozier et al. (2019) looked at methods of increasing climate resilience in their 2019 climate vulnerability assessment for Pacific salmon and steelhead. They found that reducing anthropogenic stressors could greatly improve responses to climate change by improving the overall status of a DPS in terms of abundance, productivity, spatial structure, and diversity. A robust DPS has greater resilience by virtue of strong population dynamics that make stochastic extinction less likely. Actions implemented to ameliorate limiting factors for any population would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced.

These benefits will accrue in four of the five MPGs in this DPS: the Grande Ronde, Clearwater River, Salmon River, and Lower Snake River MPGs. These improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action. Further, to yield substantial improvements, it is necessary to implement a large scale and scope of habitat improvement actions (e.g., implementation over a 25-year time period or longer), and to implement actions throughout a large portion of each watershed. Thus, it is important to consider the results of the habitat actions to be implemented under this proposed action in the context of the effects of long-term implementation of habitat actions.

Mainstem habitat in the Columbia River estuary has also been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving SRB steelhead abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished rearing and migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program should continue to effectively conserve existing productive floodplain habitat and reconnect additional areas—actions that are likely to provide improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this DPS. However, other factors (e.g., ocean conditions) also influence these VSP parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan, the Double-crested Cormorant Management Plan, and the IAPMP, as well as hazing at the mainstem dams. For SRB steelhead, we expect that management of tern colonies throughout the basin is reducing mortality by a small to moderate amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Cormorant predation rates may actually increase if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that prey on juvenile steelhead are also present in the hydrosystem reach. Increasing the John Day reservoir elevation in the spring should control impacts from the Blalock Islands tern colony. The NPMP and dam angling program are expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested cormorant Management Plan, these programs are maintaining current (reduced) levels of predation, creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on SRB steelhead in the lower Columbia River and estuary has increased slightly with recent increases in the abundance of steller sea lions in the summer and fall. Losses in the Bonneville tailrace remain relatively low, averaging a little more than 1 percent. Sea lion predation downstream of Bonneville Dam, including the estuary, continues to negatively affect the productivity and abundance of SRB steelhead.

The largest harvest-related effects on SRB steelhead result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery (including the estimated effects of recreational fisheries in the lower Snake River) and estimated that harvest rates should continue to average around 6.5 percent on unclipped A-Index steelhead and about 18 percent on unclipped B-Index steelhead (including an estimated 10 percent mortality of wild-released fish). In addition, several fisheries target hatchery steelhead in the Columbia River upstream of McNary Dam and in the Snake River basin.

The past effects of artificial production programs have largely been to increase abundance and help preserve genetic resources—especially true for safety net or conservation hatchery programs during times of low abundance. However, these programs have also posed risks to natural productivity and genetic diversity. There are 13 steelhead hatchery programs in the Snake River basin, plus one kelt reconditioning program. Five of the artificial propagation programs are considered to be part of the DPS: the Tucannon River, Dworshak National Fish Hatchery, South Fork Clearwater, East Fork Salmon River, and the Little Sheep Creek River Hatchery steelhead hatchery programs. These programs provide fish for fisheries and supplement spawning to support natural populations. Little is known about how these hatcheries affect naturally spawning populations, but a comprehensive assessment of hatchery benefits and risks is underway. Overall, recent operations (which have undergone separate ESA consultation) are focused on reducing genetic effects to naturally spawning populations (relative to past operations) by incorporating natural-origin broodstock into the programs and reducing the number of hatchery origin fish on the spawning grounds. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of SRB steelhead.

The kelt program, operated by the Nez Perce Tribe, is designed to recondition naturally produced adults (primarily females) that have been captured emigrating from the Snake River or its tributaries after they have spawned, which allows them a much greater opportunity to spawn again. While this program produces relatively few spawning adults annually (generally fewer than 100 to date), they can represent a substantial fraction of the female spawners for an individual population when adult abundance is low, as it has been in recent years.

As described in Section 2.3.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area considered for SRB steelhead are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect SRB steelhead in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of SRB steelhead as high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change. However, the severity of those changes would be reduced as a result of the proposed action.

Summer-run adults could potentially respond temporally to changing environmental conditions by migrating and spawning later in time. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or flood events). Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in streams. Juveniles would be exposed to higher summer temperatures in tributaries, though juvenile migrants could potentially respond temporally by migrating earlier in the spring. Though the quality of information is mixed, sensitivity in the marine stage is likely high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur. These climate change consequences are not caused by the proposed action, and elements of the proposed action (tributary and estuary habitat restoration and research, monitoring, and evaluation programs) should help to improve the resiliency of SRB steelhead populations to expected climate change effects. In simple terms, even if the adult abundance declines as predicted under climate change, which will make recovery of this DPS more challenging, it will have declined less as a result of the proposed action because in many ways the proposed action is expected to improve the functioning of VSP parameters and thus positively contribute to the survival and recovery of the species.

The proposed action—the future operation and maintenance of the CRS (including upper Columbia River operations and Dworshak Dam winter operations to reduce TDG in the lower Clearwater River)—will have little overall effect on the seasonal hydrograph or seasonal temperatures compared to recent conditions. The seasonal hydrograph will continue to be altered, generally increasing flows in the fall and winter and reducing flows in the spring. Seasonal water temperatures will also continue to be altered, with delayed warming in the spring, delayed cooling in the fall, and reduced daily temperature variability. These effects to river conditions likely adversely affect the survival of SRB steelhead, but to an extent not readily quantified based upon the best available information.

Other operations (e.g., operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, increasing the John Day reservoir operating range during the spring to reduce avian predation, etc.) are, collectively, expected to have small negative effects, especially on juvenile migrants, but these effects should not measurably alter survival estimates between Lower Granite and Bonneville Dam.

The proposed action includes many measures to reduce the adverse effects of the passage impediments caused by the existence of the CRS, including juvenile fish passage spill, operation of juvenile bypass systems, attraction flows for adults, and the operation of adult fish ladders. In addition to these measures, the proposed flexible spring spill operation is expected to improve juvenile survival through the mainstem migration corridor for all populations, and if the flexible spring spill operation increases adult returns by up to 28 percent as hypothesized by the CSS, SRB steelhead would experience a substantial near-term improvement in productivity and adult abundance over current conditions. Adaptively managing transport operations (using juvenile migration monitoring and seasonal patterns in adult returns to guide start date decisions) will continue to improve adult returns (relative to bypassed fish).

Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this DPS (e.g., dam passage survival, population productivity, degraded tributary and estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.).

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity and likely affects marine survival (to an unknown extent) through latent mortality. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., tributary and estuary habitat, predation, etc.). Evidence shows that these actions have resulted in improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The recent downturn in adult abundance (2014 to 2019) is primarily the result of recent poor ocean conditions and not of altered tributary and mainstem habitat conditions. The proposed action carries forward structural and operational improvements since 2008 and improves upon them. Additional juvenile survival improvements are expected from the flexible spring spill operation and potential improvements resulting from reduced latent mortality are possible, and ecosystem functions should continue to increase in tributary and estuary habitats where improvement actions occur.

Climate change is a substantial threat to SRB steelhead, especially during the marine rearing phase of their life cycle. The proposed action is expected to reduce both the scope and severity of those impacts and not exacerbate them. The proposed action therefore is expected to increase the resiliency of the populations to climate change and provide time for additional recovery actions to be implemented.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of SRB steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of SRB steelhead.

2.3.5.2 Critical Habitat

Designated critical habitat for SRB steelhead includes all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to its confluence with the Snake River, as well as all river reaches of the mainstem Snake River upstream to Hells Canyon Dam. Across the 263 watersheds in the Interior Columbia Recovery Domain with PBFs for SRB steelhead, land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity. Past and current land use and water management activities have adversely affected the quality and quantity of stream and side channel areas, riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

Measures taken through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies, in the decades since critical habitat was designated have improved the functioning of spawning and rearing area PBFs. These include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. However, more improvements will be needed before many areas function at a level that supports the recovery of SRB steelhead. Under the proposed action, the Action Agencies will implement a suite of habitat actions to further improve the functioning of water quality (e.g., temperature), water quantity, substrate, floodplain connectivity, forage, and natural cover at the local scale in watersheds with spawning and rearing sites. These include enhancing flow; access; stream complexity, including floodplain connectivity; and riparian function; and screening diversions, in the Grande Ronde/Imnaha, Clearwater, Salmon, and lower Snake River subbasins. Climate change is likely to decrease streamflow (water quantity) and increase temperature (water quality) in some spawning and rearing areas, depending on their specific characteristics and locations. These risks underscore the importance of the Action Agencies' habitat restoration program, especially actions that restore riparian vegetation, streamflow and floodplain function, to improve habitat resiliency.

The environmental baseline also includes a broad range of past and present actions and activities, including effects of the hydrosystem that have affected the conservation value of critical habitat in freshwater migration corridors for SRB steelhead. Some of these past effects of CRS operations will continue under the proposed action: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and passage delays (obstructions in the juvenile migration corridor). These factors have increased the likelihood of excessive predation on juvenile and adult SRB steelhead and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The proposed action carries forward structural and operational improvements since 2008 that address these effects on PBFs and in some cases, improves upon them. The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors.

The Action Agencies also have reduced effects of their operations on juvenile salmonid travel time and survival by increasing levels of spring spill. We expect the additional flexible spring spill to 125 percent TDG to reduce water quality in the juvenile migration corridor by a small amount while having a small positive effect on obstructions at CRS projects in the lower Snake and Columbia Rivers through increased spillway passage. On the other hand, in low runoff years, higher spill levels could degrade tailrace conditions at Lower Granite, Little Goose, Lower

Monumental, and John Day Dams, increasing the risk of bird and fish predation for juvenile migrants. However, there is sufficient flexibility through the in-season management process to identify and remedy negative effects through modified spill patterns. Most adult SR steelhead enter the Columbia River after the spring spill period ends on June 20 so that there will be only very small negative effects on water quality and obstructions in the migration corridor.

Operating turbines above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction for adults (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions by a small amount because some adults will fall back or juveniles will move downstream through turbines or bypass systems.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors.

In summary, the proposed action is not likely to further limit water quantity or water quality or to increase obstructions in the juvenile or adult migration corridors by a meaningful amount. In addition, if the CSS hypothesis regarding latent mortality is correct, the flexible spill program could improve the functioning of the juvenile migration corridor to a much greater extent than indicated by the likely effects on obstructions described above.

Increasing the elevation of John Day Reservoir to cover nesting areas on the Blalock Islands will limit the risk of predation by Caspian terns by delaying nesting until about 95 percent of steelhead outmigrants have passed McNary Dam. The Action Agencies also will continue to implement measures to reduce pinniped predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the hydrosystem and the estuary, and the predation management programs for Caspian terns on the interior plateau and for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will reduce or maintain the levels of predation within the juvenile and adult migration corridors that were achieved in recent years, although cormorant predation rates may increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. The Action Agencies' proposed estuary habitat program will continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling steelhead migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of SRB steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of SRB steelhead designated critical habitat.

2.3.6 Conclusion

After reviewing and analyzing the current status of SRB steelhead and its designated critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SRB steelhead or destroy or adversely modify its designated critical habitat.

2.4 Snake River (SR) Sockeye Salmon

This section applies the analytical framework described in Section 2.1 to the SR sockeye salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the SR sockeye salmon ESU or destroy or adversely modify its critical habitat.

2.4.1 Rangewide Status of the Species and Critical Habitat

The status of the SR sockeye salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.4.1.1 Status of Species

2.4.1.1.1 Background

On November 20, 1991, NMFS listed the SR sockeye salmon ESU as an endangered species (56 FR 58619). The endangered status was reaffirmed on June 28, 2005 (70 FR 37160) and again on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that this ESU should retain its endangered status (81 FR 33468). Critical habitat was designated on December 28, 1993 (58 FR 68543). The summary that follows describes the status of SR sockeye salmon. Additional information can be found in the recovery plan (NMFS 2015c) and the most recent status review for this species (NMFS 2016b).[121]

The ESU includes all anadromous and residual sockeye salmon from the Snake River basin, and artificially propagated sockeye salmon from the Redfish Lake Captive Broodstock Program (NMFS 2015c, 70 FR 37160).[122] The ICTRT defined Sawtooth Valley sockeye salmon as the single MPG within the SR sockeye salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four extirpated, historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes). At the time of listing in 1991, the only extant population (the Redfish Lake

[121] In addition, a technical memo prepared for the status review contains more detailed information on the biological status of the species (NWFSC 2015).

[122] For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including SR sockeye salmon (81 FR 72759). The proposed change for hatchery program inclusion in this ESU was to add the Snake River Sockeye Salmon Hatchery Program. We expect to publish the final revisions in 2020.

population) had about 10 fish returning per year (NMFS 2015c). Table 2.4-1 lists the populations and hatchery programs that are part of the ESU.

Table 2.4-1. SR sockeye major population group, component populations, and hatchery programs (NMFS 2015c, 70 FR 37160).

Major Population Group	***Populations***
Sawtooth Valley	Redfish Lake Alturas Lake (extirpated) Pettit Lake (extirpated) Stanley Lake (extirpated) Yellowbelly Lakes (extirpated)
Hatchery Programs	
Hatchery programs included in ESU	Redfish Lake Captive Broodstock Program

2.4.1.1.2 Life History and Factors for Decline

Historically, adult SR sockeye salmon entered the Columbia River in June and July, migrated upstream through the Snake and Salmon Rivers, and arrived at the Sawtooth Valley lakes in August and September (Bjornn et al. 1968). Spawning in lakeshore gravels peaked in October. Fry emerged in late April and May and moved immediately to the open waters of the lake, where they fed on plankton for 1 to 3 years before migrating to the ocean. Juvenile sockeye salmon generally left the Sawtooth Valley lakes from late April through May and migrated nearly 900 miles to the Pacific Ocean. While pre-dam reports indicate that sockeye salmon smolts passed through the lower Snake River in May and June, PIT-tagged smolts from Redfish Lake passed Lower Granite Dam from mid-May to mid-July. SR sockeye salmon enter the estuary at a large size as a result of the long time they spend in the natal lakes before emigrating as juveniles to the ocean. They generally return as 4-year-old or older fish to their natal Sawtooth Valley Lake to spawn (NMFS 2015c).

SR sockeye salmon populations declined through the early- and mid-1900s, leading to an ESA-listing of the species as endangered in 1991. By the time of listing, all populations but one, the Redfish Lake population in the Sawtooth Valley, were extirpated, and that population had dwindled to fewer than 10 fish per year. In some years before 1998, no anadromous sockeye salmon returned to the Snake River basin. Many human activities contributed to the near extinction of SR sockeye salmon. The NMFS status review that led to the original listing decision attributed the decline to overfishing; irrigation diversions; obstacles to migrating fish, including dams; and eradication through poisoning. NMFS' 1991 listing decision for SR sockeye salmon noted that such factors as hydropower development, water withdrawal and irrigation diversions, water storage, commercial harvest, and inadequate regulatory mechanisms represented a continued threat to the species' existence. Since that time, our understanding of key threats has expanded to include factors affecting survival at different points in the SR sockeye salmon life cycle. Sources of mortality for adults include predation, exposure to elevated water temperatures and elevated TDG, fallback over dams, straying to non-natal streams, harvest, and disease. Sources of mortality for juveniles include hatchery effects (e.g., disease, water quality, and mechanical failure), stress of release from the hatchery, food supply (productivity) and water quality in lakes, losses during downstream passage to and through the CRS or during transport, predation, and ocean conditions (NMFS 2015c).

Before the turn of the 20th century, large runs of sockeye salmon returned annually to the Snake River basin (Evermann 1895, Selbie et al. 2007). Sockeye salmon ascended the Snake River to the Wallowa River basin in northeastern Oregon and the Payette and Salmon River basins in Idaho to spawn in natural lakes.[123] Today, the last remaining SR sockeye salmon are in the Sawtooth Valley of Idaho, and of the five lakes that formerly supported sockeye populations, only the Redfish Lake population remains (Figure 2.4.1). This population is supported by a captive broodstock program and conventional hatchery programs; reintroduction of captive broodstock progeny has included incorporating multiple releases into Redfish, Pettit, and Alturas Lakes. The Redfish Lake population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake, and Columbia Rivers and passes through eight major Federal dams to reach the ocean. After 1 to 3 years in the ocean, the fish return to the Sawtooth Valley as adults, passing once again through the eight dams. Anadromous sockeye salmon returning to Redfish Lake travel a greater distance from the sea (900 miles) and to a higher elevation (6,500 feet) than any other sockeye salmon population (NMFS 2013c, 2015c).

[123] The historical relationships between the different SR sockeye salmon populations are not known. Because of the large geographic separation between the Wallowa, Payette, and Salmon River lakes, it is possible that each drainage supported a separate ESU (ICTRT 2005).

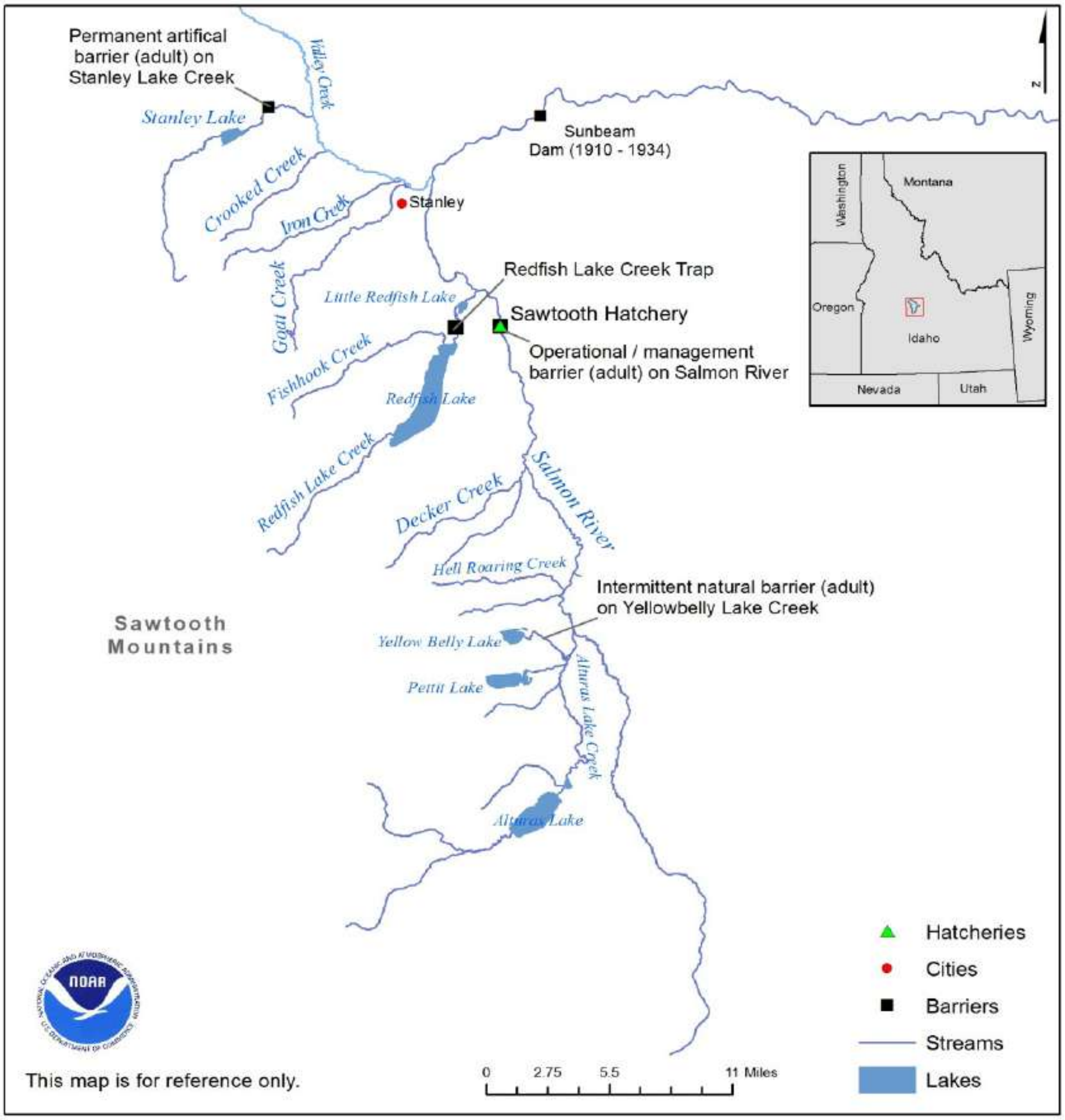

Figure 2.4-1. Map of SR sockeye salmon spawning areas and barriers in the Stanley Basin and Sawtooth Valley, Idaho.

2.4.1.1.3 Recovery Plan

The ESA recovery plan for SR sockeye salmon (NMFS 2015c) includes delisting criteria for the ESU, along with identification of factors currently limiting the recovery of the ESU, and management actions necessary for recovery. Biological delisting criteria are based on recommendations by the ICTRT.[124] They are hierarchical in nature, with ESU-level criteria based on the status of natural-origin SR sockeye salmon assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk

[124] The recovery plan also includes "threats criteria" for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

characterization. Achieving recovery (i.e., delisting) of the ESU will require sufficient improvement in its abundance, productivity, spatial structure, and diversity.

The ICTRT recommended that the long-term recovery scenario for SR sockeye salmon should include restoring at least two of the three historical lake populations in the ESU to highly viable, and one to viable status, using Redfish Lake, Alturas Lake, and Pettit Lake. As recovery efforts progress over time, the ICTRT recommended considering expansion of reintroductions into Yellowbelly Lake and Stanley Lake (NMFS 2015c).

The SR sockeye salmon ESU is at a high risk of extinction. The recovery strategy aims to reintroduce and support adaptation of naturally self-sustaining sockeye salmon populations in the Sawtooth Valley lakes. The recovery strategy has three phases: 1) preservation with the captive broodstock program, 2) reintroduction, and 3) a program emphasizing natural adaptation and viability. At this time, we are still working on the first two phases; reintroduction efforts using Redfish Lake stock have been ongoing in Redfish Lake since 1993, Pettit Lake since 1995, and Alturas Lake since 1997 (Figures 2.4-1 and 2.4-2).

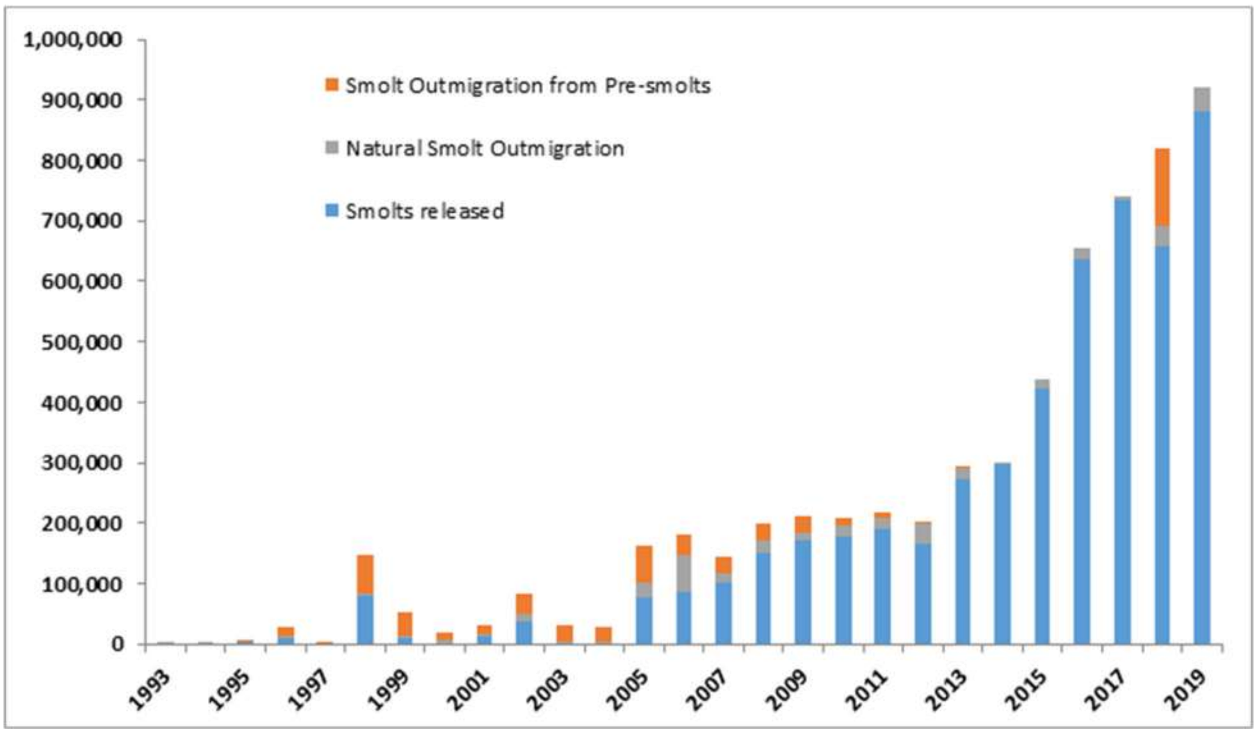

Figure 2.4-2. Estimated annual numbers of sockeye salmon smolt outmigrants from the Sawtooth Valley basin. This includes all hatchery smolt releases, known outmigrants originating from hatchery presmolts, and estimates of unmarked juveniles from Redfish, Alturas, and Pettit Lakes (Bellerud 2020).

2.4.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

In its recovery plan and most recent status review, NMFS noted that approximately two-thirds of the returning adults each year were captured at the Redfish Lake Creek weir, with the remaining adults captured at the Sawtooth Hatchery weir on the mainstem Salmon River upstream of the Redfish Lake Creek confluence. Although total SR sockeye salmon returns to the Sawtooth

Basin were high enough to allow for some level of spawning in Redfish Lake, the hatchery program's priority remained genetic conservation and building sufficient returns to support sustained outplanting and recolonization of the species' historical range (NMFS 2015c, 2016b).

Adult returns of sockeye salmon to the Sawtooth Basin showed a general pattern of increase through 2014 (Table 2.4-2) (Johnson et al. 2020). In the 7 years before 2015, adult returns varied from a low of 242 in 2012 (including 52 natural-origin fish) to a high of 1,516 in 2014 (including 453 natural-origin fish). The large increases in returning adults in those years reflected improved survival during downstream migration through the mainstem Salmon, lower Snake, and Columbia Rivers and in the ocean, as well as increases in juvenile production since the early 1990s (NMFS 2016b).

Table 2.4-2. Hatchery- and natural-origin sockeye salmon returns to Sawtooth Valley, 1999 to 2019 (NMFS 2015c, Johnson et al. 2020).

Return Year	Total Return	Natural Return	Hatchery Return	Alturas Returns[1]	Observed Not Trapped
1999	7	0	7	0	0
2000	243	10	233	0	14
2001	23	4	19	0	3
2002	15	6	9	1	7
2003	2	0	2	0	1
2004	24	4	20	0	3
2005	6	2	4	0	0
2006	3	1	2	0	0
2007	4	3	1	0	0
2008	598	140	458	1	51
2009	817	86	731	2	16
2010	1,322	178	1,144	14	33
2011	1,099	145	954	2	18
2012	242	52	190	0	15
2013	270	79	191	0	2
2014	1,516	453	1,062	0	63
2015[2]	91	28	63	0	0
2016	572	33	539	0	23
2017	162	11	151	0	24
2018	113	13	100	0	3
2019	17	14	3	0	0

[1] These fish were assigned as sockeye salmon returns to Alturas Lake and are included in the natural-return numbers.

[2] In 2015, 56 sockeye returned to the Sawtooth Valley and 35 Snake River basin-origin sockeye were transported from Lower Granite Dam.

In 2015, the trend of adult returns was interrupted. Although the largest estimated number of SR sockeye salmon adults in recent history (4,093) arrived at Bonneville Dam that year, elevated water temperatures resulted in only 1 percent survival from Bonneville to Lower Granite Dam. Agencies and stakeholders quickly implemented a transportation program in which sockeye salmon were captured at Lower Granite Dam and trucked to the Sawtooth Valley to avoid the high temperatures. Fortunately, the "safety net" captive broodstock program was able to provide adults to maintain the SR sockeye salmon hatchery program (NMFS 2013c). In addition to the high temperature issue, the hatcheries had operational issues during 2015 to 2017 that resulted in high mortalities. It now appears that the operational issues are resolved or close to resolution. The low return of adults to the Sawtooth Valley in 2015 and the hatchery juvenile production issues in 2015 to 2017 (see Section 2.4.2.2) likely contributed, along with recent poor ocean conditions, to the lower 2017 to 2019 SR sockeye salmon returns compared to previous years. There is also increasing evidence that competition with extremely large numbers of hatchery produced pink salmon, combined with a warm ocean, are substantially reducing the productivity (and abundance) of southerly populations of west coast sockeye salmon—especially in odd years, when adult pinks are far most abundant (Connors et al. 2020).

Long-term recovery objectives for this ESU are framed in terms of natural production. Substantial progress has been made with the captive broodstock hatchery program, but natural production levels of anadromous returns remain extremely low for this ESU.

2.4.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect SR sockeye salmon provides important information and perspective regarding the status of the species. One of the necessary steps in achieving species' recovery and delisting is to ensure that the underlying limiting factors and threats have been addressed. Limiting factors and threats identified in the recovery plan (NMFS 2015c) for this ESU include (in no particular order):

- Natal lake habitat: In the Sawtooth Valley natal lakes, limiting factors include blocked access; low zooplankton density (which can restrict sockeye salmon growth and fitness); current and legacy effects of land use and other human activities such as mining, grazing, recreational use, lakeshore development, and irrigation diversions; lake poisoning;[125] and introduction and continued stocking of non-native species (such as brook trout, rainbow trout, lake trout, and kokanee).
- Mainstem Salmon River habitat: In the mainstem Salmon River migration corridor, irrigation withdrawals have contributed to reduced baseflows, altered hydrologic regimes, elevated water temperatures, and reduced availability of thermal refugia; the presence of toxic compounds has the potential to impair fitness; historical and current land uses have led to degraded riparian, floodplain, and instream habitat, elevated water temperatures, elevated sediment levels, and barriers to migration; and emigrating juveniles are subject to predation by smallmouth bass, hatchery steelhead, hatchery rainbow trout, and brook trout.
- Lower Snake River habitat upstream of Lower Granite Reservoir: Operation of the Hells Canyon Complex dams has altered flows, riparian function, and food webs, and land use

[125] In the 1950s, based on very low levels of adult sockeye salmon returns to Stanley, Pettit, and Yellowbelly Lakes, the IDFG made the decision to develop these lakes for resident species sport fisheries. Yellowbelly, Pettit, and Stanley Lakes were chemically treated with Toxaphene, Rotenone, and Fish-Tox, but the larger Alturas and Redfish Lakes were not.

adjacent to the Snake River and its tributaries has degraded water quality and altered the thermal regime.

- Mainstem CRS migration corridor: Federal hydropower dams have created passage barriers and conversion of riverine habitat to reservoirs, and water withdrawals have degraded habitat conditions.
- Estuary habitat: Dikes, levees, and hydrosystem flow operations have disconnected the river from much of its historical floodplain, eliminating shallow-water habitat and altering the food web; water temperatures in the estuary during summer months are also higher than they were historically.
- Hatcheries: The Redfish Lake Sockeye Captive Broodstock Program has been vital to conserving genetic resources and helping SR sockeye salmon avoid extinction. As the program transitions to a larger scale supplementation program, the potential exists for loss of genetic diversity due to hatchery fish spawning with natural-origin fish (NMFS 2013c).
- Harvest: There are no fisheries targeting SR sockeye salmon, and fisheries targeting other Snake River species are managed to protect SR sockeye salmon. Non-Indian fisheries in the lower Columbia River are limited to an incidental take rate of 1 percent of the SR sockeye salmon adults reaching the Columbia River mouth, and Treaty Indian fisheries are limited to an incidental take rate of 5 to 7 percent, depending on the run size of upriver sockeye salmon stocks
- Predation: The recovery plan identified potential concerns related to predation by native and non-native fishes, predation by birds, and predation by marine mammals.

In its most recent status review, NMFS (2016b) noted that:

- Improvements had been made in tributary and estuary habitat conditions due to restoration and protection efforts, but habitat concerns remain throughout the Snake River basin, particularly in regard to streamflow, floodplain management, and water temperature.
- Changes to hydropower operations and passage had increased juvenile survival rates.
- Hot summer temperatures and impaired migration conditions in 2013 resulted in approximately 30 percent of the migrating adult SR sockeye salmon failing to pass Lower Granite Dam. In 2015, in response to high water temperatures, regional fish managers collected adult SR sockeye salmon at Lower Granite Dam and transported them to the Eagle Hatchery in Idaho.
- The adoption of the 2008 to 2017 *U.S. v. Oregon* Management Agreement had, on average, reduced impacts of freshwater fisheries to all Snake River ESUs/DPSs.
- Extirpation and further loss of genetic diversity of SR sockeye salmon had been averted largely due to the hatchery broodstock program, and the program was adjusting to

promote increases in population diversity, spatial structure, and long-term recovery of the ESU.

- New information indicated that avian and pinniped predation had increased since the previous status review, although specific information on impacts to SR sockeye salmon was not available.
- Regulatory mechanisms had in general improved since the previous status review.
- Uncertainty regarding the long-term impacts of climate change and the ability of SR sockeye salmon to adapt added additional risks to species recovery.
- Key protective measures included continued releases of cool water from Dworshak Dam during late summer, continued flow augmentation to enhance flows in the lower Snake River in July and August, and continued efforts to improve adult passage at Lower Granite Dam.

2.4.1.1.6 Information on Status of the Species since the 2016 Status Review

The best scientific and commercial data available indicate a substantial downward trend in the returns of hatchery-origin and natural-origin adults to the Sawtooth Valley since 2014 (Table 2.4-2). The 5-year geometric mean of total spawner counts declined 6 percent in 2014 to 2018 when compared to 2009 to 2013 (Table 2.4-3).[126]

The recent downturn in adult abundance is thought to be driven primarily by marine environmental conditions and a decline in ocean productivity (see discussion below), because the effects of hydropower operations and the overall availability and quality of tributary and estuary habitat were relatively constant or improving over the past 10 years.[127] However, adult returns of SR sockeye salmon to the Sawtooth Valley were also significantly impacted by earlier than average warm water temperatures in the mainstem in 2015. And hatchery operations faced significant water chemistry issues in 2015 to 2017 that resulted in the very poor survival of outplanted juveniles as they made their way through the hydrosystem (Section 2.4.2.2). Those hatchery practices have been modified significantly, and early indications are positive that water chemistry is no longer a significant source of mortality in the hydrosystem for hatchery-origin juveniles.

[126] The upcoming status review, expected in 2021, will include population-level adult returns through 2019, and will add an updated 5-year geomean, for 2015 to 2019. Because the 2014 adult returns represented a peak (Table 2.4-2), the negative percent change between the 2015–2019 and 2014–2018 geomeans will likely be greater than that shown in Table 2.4-3 between the 2014–2018 and 2009–2013 geomeans.

[127] Many factors (e.g., higher summer temperatures, lower late summer flows, low spring flows, etc.) affect the ability of tributary habitat to produce juvenile migrants (capacity) each year. Recent drought and temperature patterns may have had a negative effect on tributary habitat productivity, and as a result, lower than average juvenile production may have contributed in some years to downturns in adult abundance.

Table 2.4-3. 5-year geometric mean of total spawner counts for SR sockeye salmon. "% change" is between the two most recent 5-year periods. At the time of drafting this opinion, 2019 data were not available. "NA" means not available. Source: Williams (2020a).

Population	MPG	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change
Sawtooth Valley	Redfish Lake	NA	NA	(244)	(395)	(977)	(923)	(-6)

NMFS will evaluate the implications for viability risk of these more recent returns in the upcoming 5-year status review, expected in early 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.4-2 and Table 2.4-3.

Since 2016, observations of coastal ocean conditions indicate that recent outmigrant year classes have experienced below-average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict the drop in adult Chinook salmon returns observed through 2019 (Werner et al. 2017). These conditions are also likely to have affected sockeye salmon returns. Some of the negative impacts on juvenile salmonids had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 50-meter surface layer) had not returned to normal (Harvey et al. 2019). Expectations for marine survival are relatively mixed for juveniles that reached the ocean in 2019 (Zabel et al. 2020). There is also increasing evidence that the increasing abundance of pink salmon across the North Pacific Ocean, driven in large part by extremely large and increasing hatchery releases from Alaska, Russia, and other Pacific Rim countries, are substantially depressing the abundance of odd year sockeye returns (Connors et al. 2020)

2.4.1.2 Status of Critical Habitat

NMFS designated critical habitat for SR sockeye salmon to include all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to its confluence with the Snake River, as well as all river reaches of the mainstem Snake River upstream to its confluence with the Salmon River, and all Salmon River reaches upstream to Alturas Lake Creek; Stanley, Redfish, Yellow Belly, Pettit, and Alturas Lakes (including their inlet and outlet creeks); and the portion of Valley Creek between Stanley Lake Creek and the Salmon River. Critical habitat also includes all river lakes and reaches presently or historically accessible (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams) to Snake River sockeye salmon in the following watersheds: Lower Salmon, Lower Snake, Lower Snake-Asotin, Lower Snake-Tucannon, Middle Salmon-Chamberlain, Middle Salmon-Panther, and Upper Salmon (50 CFR 226.205(a)).

The mainstem Columbia and Snake River migration corridor is among the areas of high conservation value to the ESU because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults.[128] Critical habitat also includes river reaches presently or historically accessible, except those above impassable natural falls and Dworshak and Hells Canyon Dams, in seven subbasins with tributaries to the Salmon and lower Snake Rivers (NMFS 1993).

The PBFs identified when critical habitat was designated are essential to the conservation of the SR sockeye salmon ESU because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). For example, the PBFs of freshwater spawning and rearing areas for SR sockeye salmon include spawning gravel, water quality and quantity, water temperature, food, riparian vegetation, and access (Table 2.4-4).

Table 2.4-4. Physical and biological features (PBFs) of critical habitats designated for SR sockeye salmon, and corresponding species life history events.

Physical and Biological Features	Components of the PBFs
Spawning and juvenile rearing areas	Spawning gravel Water quality Water quantity Water temperature Food Riparian vegetation Access
Adult and juvenile migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food (juvenile migration corridors) Riparian vegetation Space Safe passage
Areas for growth and development to adulthood	Ocean areas – not identified

The complex life cycle of SR sockeye salmon gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and support later emergence or escape from the gravel of alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including plankton and insects. During their downstream migration, they need instream places to hide from predators (mostly birds and larger fish) such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas, and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead rely on limited stored energy to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of

[128] NMFS did not rate the conservation value of specific watersheds for Snake River salmon as it did in subsequent designations for other species (NMFS 2005b).

contaminants and migratory corridors with adequate passage conditions to allow access to the various habitats required to complete their life cycle.

The following sections discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary Recovery Domains.[129]

2.4.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia Recovery Domain, which includes the Snake River basin, for SR sockeye salmon. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development (NMFS 2015c). In many areas, critical habitat has been degraded by intense agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems that negatively affect the function of critical habitat in developed areas.

Most of the historical spawning and rearing area for SR sockeye salmon in Redfish, Pettit, Alturas Stanley, and Yellowbelly Lakes, lies within an undeveloped wilderness area. Overall, habitat conditions in these high mountain lakes remain in relatively pristine condition (NMFS 2015c). The lakes are, and were historically, oligotrophic (lacking in nutrients) and with relatively low natural aquatic productivity compared to lakes at lower elevations. Summer water temperatures in the lakes temporarily spike to levels that make sockeye salmon more susceptible to disease and infection, and the introduction and continued stocking of non-native fish species such as brook trout, lake trout, and kokanee creates competition and predation risks. Providing connectivity of migratory corridors and increasing spatial distribution is critical to successful SR sockeye salmon recovery. Volitional passage is now available for fish returning to Redfish Lake, but a weir at Sawtooth Hatchery restricts passage in the Salmon River for adult sockeye salmon that do not enter the trap. Providing effective passage at the weir will be critical to restoring demographic characteristics and establishing migration corridors to Alturas and Pettit Lakes, and is therefore an important early step in the recovery strategy. An artificial barrier on Stanley Lake Creek also prevents access to Stanley Lake. Potential removal of this barrier will receive further consideration.

Construction of large hydropower and water storage projects associated with the CRS further affected salmonid migratory conditions and survival rates. As noted above, the production of SR sockeye salmon was especially impacted by the development of eight major Federal dams and reservoirs in the mainstem lower Columbia/Snake River migration corridor between the late 1930s and early 1970s. Hydrosystem development also modified natural flow regimes, resulting

[129] A recovery domain is an administrative unit for recovery planning defined by NMFS based on species boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed species.

in warmer late summer and fall water temperatures. Changes in fish communities led to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines and juvenile bypass systems, also have killed some outmigrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented improvements in the juvenile and adult migration corridors, including 24-hour volitional spill, improved surface passage routes, improved juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

Many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain are over-allocated, with more allocated water rights than existing stream flow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a major limiting factor for SR sockeye salmon (NMFS 2015c).

Summer water temperatures are elevated in many tributary stream reaches across the Snake River basin and exceed water quality standards (NMFS 2017a). NMFS (2015c) identified reduced streamflow and elevated temperatures in the Salmon River during late summer, when adult SR sockeye salmon are returning to their natal lakes, as a potential limiting factor. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat. They can negatively impact critical habitat and the organisms associated with these areas.

2.4.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat has also been designated for SR sockeye salmon in the lower Columbia River estuary. For the purpose of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained the dynamic environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels; marsh and riparian habitats have been filled and diked; and causeways have been constructed that restrict the position of tributary confluences. Over time, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington), although large amounts of sediment enter the estuary from the Willamette River and other large tributaries on the Washington shoreline.

Dampening of the historical variability in mainstem flows in the lower river through storage and release operations at upstream reservoirs may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has reduced the delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The combined effect of these changes is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs, and thus the conservation value of critical habitat for SR sockeye salmon within the action area, are discussed in more detail in the Environmental Baseline section, below.

2.4.1.3 Climate Change Implications for SR Sockeye Salmon and Critical Habitat

One factor affecting the rangewide status of SR sockeye salmon and aquatic habitat is climate change. The USGCRP[130] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[131] as follows:

[130] http://www.globalchange.gov

[131] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, earlier emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003, Crozier et al. 2008a, Martins et al. 2012, Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy among interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- Direct effects of increased water temperatures on fish physiology.
- Temperature-induced changes to stream-flow patterns which can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.
- Alterations to freshwater, estuarine, and marine food webs, which alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity, which have changed the abundance and productivity of fish resources.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011). This occurred in 2015, when about 475,000 adult sockeye salmon (all ESUs) passed Bonneville Dam in the Columbia River, but only 2 to 15 percent of these adult sockeye, depending upon the population, survived to their spawning grounds. Most died in the lower Columbia River beginning in June when the water warmed to above 68°F, the temperature at which sockeye salmon begin to die. Water temperatures rose to 73°F in July, when the area experienced a combination of continued high summer temperatures and lower than average flows (due to the lower snowpack from the previous winter and drought conditions exacerbated due to increased occurrences of warm weather patterns) (NMFS 2016b). In 2015, only 14 percent of adult SR sockeye salmon survived from Bonneville to McNary Dam, and only 4 percent survived from Bonneville to Lower Granite Dam (NMFS 2016b).

Crozier et al. (2019) recently completed a climate vulnerability assessment for Pacific salmon and steelhead, including SR sockeye salmon. They concluded that this species has a very high risk of overall climate vulnerability based on its very high risk for biological sensitivity, high risk for climate exposure, and low capacity to adapt.[132] Life-stage sensitivity attributes for this ESU were scored very high for the adult freshwater stage, which essentially caused the very high score in cumulative life-cycle effects. Rates of adult and juvenile migration survival are strongly correlated with temperature in the Columbia River, and catastrophic effects of temperature on the adult migration have been observed recently. Adult migration survival for SR sockeye salmon to spawning grounds ranged from 1 percent in the extremely warm year of 2015 to 60 percent in the more average year 2010 (Crozier et al. 2015, 2018). The anadromous run essentially disappeared altogether in the early 1990s, and has rebounded somewhat in recent years due to large releases of captive broodstock and improved ocean survival (Williams et al. 2014, NWFSC 2015). Ocean survival is well predicted by environmental climate indices, particularly upwelling and the Pacific Northwest Index (Williams et al. 2014). However, the impact of climate change specifically on marine survival is uncertain, leading to a moderate score for the marine stage.

SR sockeye salmon were scored low in estuary stage sensitivity because of their rapid migration from fresh water to the early marine stage. Risk during early life history was also scored low because of the high elevation and relatively stable lake temperatures that influence the egg stage. Scores for the juvenile freshwater stage were spread across many bins (sd = 0.89) due to uncertainty in how juvenile rearing and migration would be affected by climate change. The primary rearing lake is likely to remain suitable for sockeye, but the long-distance migratory stage is sensitive to reduced freshets that will result from reduced snowpack. Because smolt production is now dependent on hatchery releases, there is great uncertainty in how management and fish condition will change in the future. Many juveniles are transported past the eight dams along their migration route, which improves juvenile survival but has negative effects on marine survival and adult migration success (Crozier et al. 2015, 2018). All these anthropogenic

[132] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results.

influences make predictions about natural-origin sockeye difficult. In exposure attributes, this ESU was scored as very high risk for stream temperature and ocean acidification and high risk for hydrologic regime and sea surface temperature.

SR sockeye salmon scored low in adaptive capacity. Sockeye salmon are unlikely to respond to climate change by changing their life-history characteristics, other than reverting to a fully freshwater life history, which would constitute the complete loss of a fundamental characteristic of this ESU. The resident population in Redfish Lake has already contributed significantly to the present anadromous broodstock. Furthermore, little potential habitat exists that might improve in suitability. Low population abundance and spatial diversity suggest limited genetic heterogeneity that would support rapid adaptation. Adult migration spans a broad temporal window (April to mid-August), which might contract to avoid high temperatures and low flows in summer, as has been observed in the larger Okanogan and Wenatchee sockeye ESUs (Crozier et al. 2011).

2.4.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce fitness of salmonids, including SR sockeye salmon (Beechie et al. 2013, Wainwright and Weitkamp 2013, Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a, Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are others where it is detrimental (Sykes et al. 2009, Whitney et al. 2016).

2.4.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location (Crozier et al. 2008b, Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b, Beechie et al. 2013). However, river flow is already becoming more variable in many rivers and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely that this increasingly variable flow is detrimental to multiple salmon and steelhead populations in the Columbia River basin.

The effects of climate change on stream ecosystems are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes are likely to lead to shifts in the distributions of native species and facilitate establishment of exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016, Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.4.1.3.3 Estuarine Effects

In estuarine environments, the two greatest concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013, Limburg et al. 2016). Estuaries will be affected directly by sea-level rise; as sea levels rise, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010, Wainwright and Weitkamp 2013, Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006, Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict inward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species and life history types are highly reliant on estuarine wetlands for rearing, many populations use them extensively (Jones et al. 2014). Others, such as SR sockeye salmon, benefit from the influx of prey from the floodplain to the mainstem migration corridor (Johnson et al. 2018, PNNL and NMFS 2018, 2020).

2.4.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010, Asch 2015, Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years. For example, range extensions were documented in many species from southern California to Alaska during unusually warm water associated with the marine heatwave known as "the blob" in 2014 and 2015 (Bond et al. 2015, Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002, Fisher et al. 2015). The frequency of extreme conditions such as those associated with marine heatwaves or El Niño events is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015, Rehage and Blanchard 2016). While it is certain that these effects will occur, current models cannot predict the composition or outcomes of future trophic interactions. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm ocean conditions, suggesting that, at a minimum, prey availability and prey quality, "bottom-up" drivers of growth and survival, may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem[133] (Bograd et al. 2009, Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014, Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean (Tomaro et al. 2012), and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska, and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007, Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in Alaska salmon productivity and survival (Mantua et al. 1997, Martins et al. 2012). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009, Martins et al. 2012). However, more recent information indicates that Alaska salmon, which have historically contrasted with southern populations by benefitting from warm phases of the PDO, no longer have a positive correlation with winter sea-surface temperature (Litzow et al. 2018) and are more synchronized with southern populations (Ohlberger et al. 2016). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

[133] The California Current moves southward along the western coast of North America, beginning off southern British Columbia and ending off the southern Baja California Peninsula.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015, Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.4.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change in general, including in the Pacific Northwest. The indirect effects of climate change are also uncertain, including whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013, Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will involve the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life history characteristics among stocks of salmon may lead to large differences in their response (Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning that some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm. Observations from 2015 (see Section 2.4.2.1.5, Adult Migration/Survival) demonstrate that migrating adult SR sockeye salmon are vulnerable to warmer summer water temperatures, suggesting that this species will be harmed by climate change effects in the future.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is less certain, leading to a range of potential future outcomes.

2.4.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to the listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For SR sockeye salmon, we focus our description of the environmental baseline on areas where juveniles and adults are most exposed to the effects of the proposed action. We also consider the broader action area, including spawning and rearing areas in the Upper Salmon subbasin because these areas provide important context for understanding the effects of the proposed action. The area in which SR sockeye salmon are exposed to the effects of the proposed action includes all waters within the lower Columbia River from the mouth and plume[134] through the lower Snake and the Salmon River to the Upper Salmon subbasin where SR sockeye salmon are present. This includes all waters impounded by Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams and tributary confluences in this reach to the extent they have been inundated by mainstem reservoirs or are affected by flow management.

2.4.2.1 Mainstem Habitat

Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., smallmouth bass, walleye, channel catfish, invertebrates, etc.), and other human activities that have degraded water quality and habitat.

2.4.2.1.1 Seasonal Flows

On the mainstem Snake135 and Columbia Rivers, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower

[134] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

[135] The effects of the operation and maintenance of 10 Reclamation projects and two related actions in the upper Snake River above Brownlee Reservoir, including the 2004 Nez Perce Water Rights Settlement and the Snake River Water Rights Act of 2004 (for a 30-year period through 2034; USBR 2007), underwent consultation in 2008 (NMFS 2008a, b).

demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.4-3). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

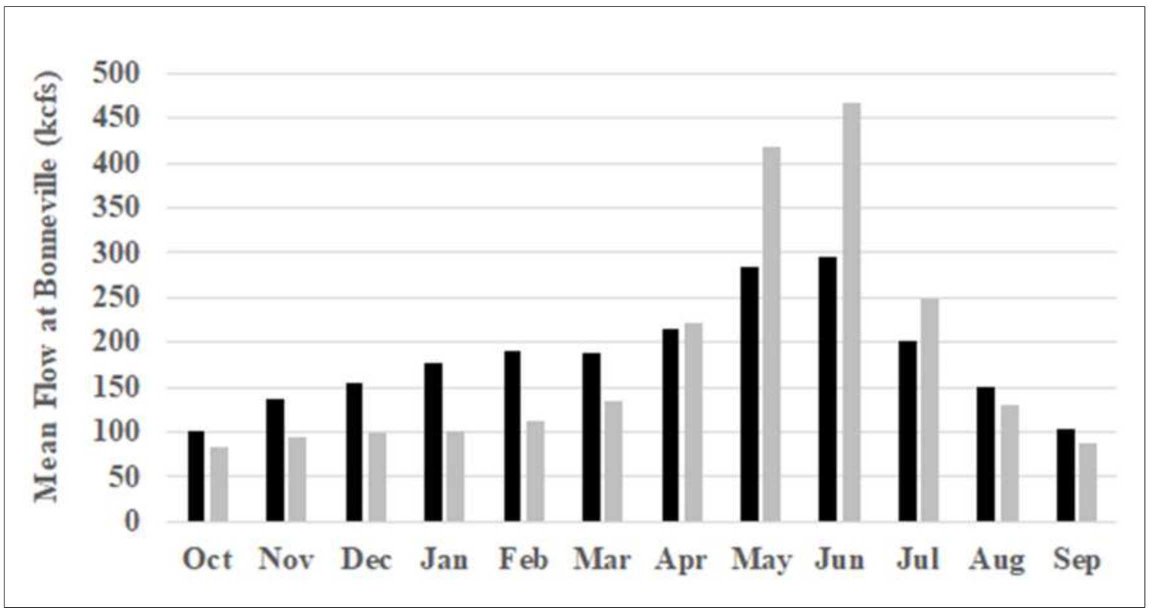

Figure 2.4-3. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[136] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

[136] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year (Table 2.4-5). This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile SR sockeye salmon and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

Table 2.4-5. Seasonal flow objectives and planning dates for the mainstem Columbia and Lower Snake Rivers. NA indicates that there is not a flow objective for the season at these projects.

Location	Spring		Summer	
	Dates	Objective (kcfs)	Dates	Objective (kcfs)
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100[a]	6/21 to 8/31	50 to 55[a]
Columbia River at McNary Dam	4/10 to 6/30	220 to 260[a]	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 to 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160[b]	NA	NA

[a] Objective varies based on actual and forecasted water conditions.

[b] Objective varies according to water volume forecasts and is for chum salmon (spawning period is approximately November 1 through December and protection flow objectives are based on redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

Seasonal flow objectives for improving the migration and survival of spring and summer juvenile migrants are based on water supply forecasts; however, mean seasonal flows in the past did not always achieve the flow objectives when measured as a seasonal average flow. From 1998 to 2019, seasonal spring flow objectives were met or exceeded during 81 percent of years at McNary Dam and during 48 percent of years at Lower Granite Dam. For the years when the spring flow objectives were not met, the average seasonal flow was 88 percent of the spring flow objective at McNary Dam and 78 percent of the spring flow objective at Lower Granite Dam.

Across all years, the average percentage of the spring flow objective obtained was 113 percent at McNary Dam and 101 percent at Lower Granite Dam. Achieving these seasonal flow objectives provides multiple benefits for smolts in the migration corridor, estuary, and plume. Higher spring flow helps reduce fish travel time, increases juvenile access to shallow water habitat along the river banks, increases the flux of invertebrate prey to shoreline habitat, increases turbidity (which can reduce predation on juvenile migrants), and increases the size of the Columbia River plume, which is a key transition corridor for smolts to the nearshore ocean environment. Conversely, when seasonal flow objectives are not met, juvenile survival may be reduced via these same pathways of ecological effects.

From 1998 to 2019, summer flow objectives were met or exceeded during 14 percent of years at McNary Dam and during 18 percent of years at Lower Granite Dam. For the years when the summer flow objectives were not met, the average seasonal flow was 74 percent of the summer flow objective at McNary Dam and 66 percent of the summer flow objective at Lower Granite Dam. Across all years, the average percentage of the summer flow objective obtained was 85 percent at McNary Dam and 79 percent at Lower Granite Dam. The benefits provided by attaining summer flow objectives, and potential impacts associated with not meeting them, are the same as those previously described for the spring flow objectives.

Recommendations on when to manage flows for the benefit of juvenile passage are made by the TMT during the juvenile migration season. These recommendations are informed by the status of the juvenile migration, water supply forecasts, river flow conditions, and river flow forecasts during the juvenile migration season.

2.4.2.1.2 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult SR sockeye salmon is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of SR sockeye salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Snake and Columbia Rivers is a concern; because of temperature standard exceedances, both rivers are included on the Clean Water Act §303(d) list of impaired waters established by Oregon, Washington, and Idaho. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges from cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

Since the mid-1990s, the Corps has released up to 1.2 million acre-feet of cool water from Dworshak Dam annually on the North Fork Clearwater River to reduce temperatures and enhance flows in the lower Snake River from June or July to September. Operators manage releases from Dworshak Dam so that water temperature at the tailrace of Lower Granite Dam does not exceed 68°F (20°C). This action reduces temperatures in the lower Clearwater River, and the Snake River from the confluence with the Clearwater River to at least Lower Monumental Dam, but has little to no discernible effect on temperature in the Columbia River downstream of the Snake River confluence. Even with the flow augmentation from Dworshak Dam for cooling, temperature criterion exceedances occur frequently at Little Goose, Lower Monumental, and Ice Harbor Dams from mid-July to mid-September (EPA 2020).

The releases from Dworshak Dam cool the lower Clearwater River and Lower Granite Reservoir substantially, although the cooler water is denser and sinks to the bottom, causing vertical stratification of the reservoir. As this water flows downstream, warmer surface water mixes with the cooler, deeper water as it passes through turbines and spillbays at Lower Granite Dam and each subsequent Snake River dam until the cooling effect becomes attenuated below the tailrace of Ice Harbor Dam (NMFS 2008a, 2017a). Figure 2.4-4 depicts this downstream attenuation during the high temperature conditions in 2015. Temperatures were warmest at the Anatone Gage on the Snake River upstream of Lower Granite Reservoir before it was influenced by cooler water from Dworshak Dam. Temperatures were coolest at the Peck Gage on the Clearwater River below Dworshak Dam, and tailrace temperatures proceeding downstream at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams increased at each project. Thus, even in an unusually warm, low-flow year, the cool-water releases from Dworshak Dam substantially improved the summer migration conditions for adult SR sockeye salmon in the lower Snake River compared to the high temperatures that would have been present at these projects without flow augmentation for temperature control. The difference in temperatures after mid-June observed at the Anatone Gage without the cooling effect from Dworshak Dam releases (approximately 22°C to 24°C) compared to that at Lower Granite Dam with the coldwater releases from Dworshak Dam (approximately 18°C to 21°C) is biologically significant; the Oregon and Washington temperature standards for migrating adult salmon both are 20°C (daily maximum or 7-day average daily maximum; EPA 2020), above which survival and reproductive success are expected to decline.

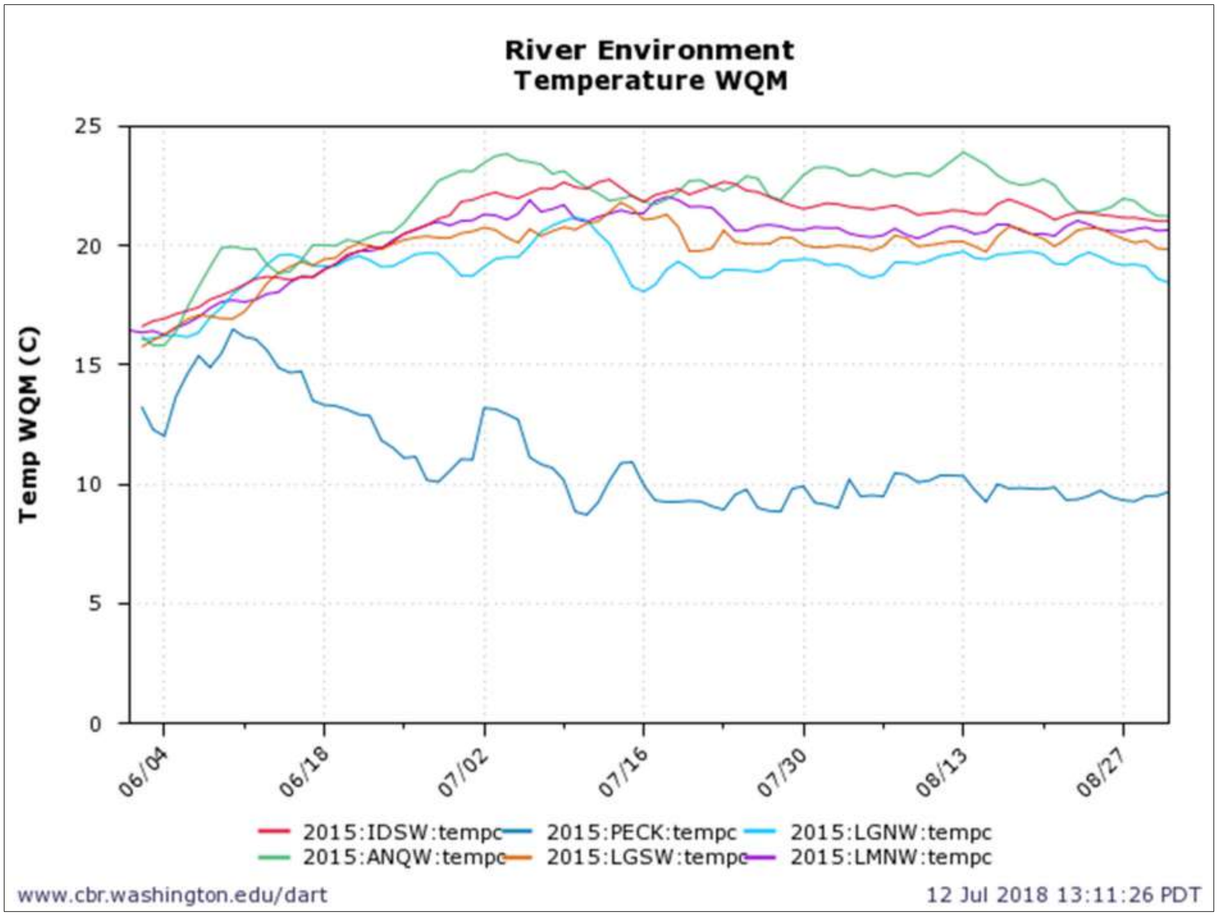

Figure 2.4-4. Water temperature at the Anatone Gage on the Snake River upstream of the Clearwater River confluence (ANQW, green); the Peck Gage on the lower Clearwater River (PECK, dark blue); and, in order from upstream to downstream located below the Clearwater River confluence, the tailrace temperatures at Lower Granite (LGNW, light blue), Little Goose (LGSW, orange), Lower Monumental (LMNW, purple), and Ice Harbor (IDSW, red) dams during summer, 2015.

The Corps also operates fishway exit cooling pumps at Lower Granite and Little Goose Dams to minimize adult passage delays associated with localized temperature differentials between these adult ladders and project forebays, which can potentially improve adult survival rates.

PIT-tag data indicate that SR Sockeye adults historically pass Bonneville Dam in late June to early July (DART 2020e). During some years, warm river temperatures have affected adult sockeye during migration negatively (e.g., 2015) but due to thermal inertia from reservoirs, warm temperatures are more likely to be a problem later in the summer.

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the middle and lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam except The Dalles Dam. Biological monitoring (smolts sampled from the juvenile bypass systems at many mainstem dams) shows that the incidence of observed GBT symptoms in both migrating smolts and adults remains between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces.[137] When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[138] Under recent operations (2008 to 2019), exposure to elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June. In studies to date, clearly defining the relationship between survival of SR sockeye salmon and TDG has been difficult due to small sample sizes and autocorrelation of TDG with other environmental

[137] Monitoring at the Lower Granite Dam trap in 2018 (experiencing higher court-ordered spill operations) and in 2019, showed that GBT and headburn symptoms on adult steelhead and Chinook salmon were similar in prevalence relative to past years (Corps' Lower Granite Adult Trap database accessed on December 10, 2019, and Ogden 2018b). Headburn refers to lesions and ulcers on the heads and jaws of migrating adults that can result from contact with concrete and other structures at dams, and which can increase prespawn mortality (Neitzel et al. 2004).

[138] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

variables; however, more robust datasets for Chinook salmon and steelhead do not clearly indicate that survival rates have been reduced by increased exposure to TDG.

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

2.4.2.1.3 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of SR sockeye salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[139] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[140] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

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[139] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[140] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

Sediment Transport

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

NMFS completed formal consultation for the Channel Maintenance Dredging in the lower Snake and Clearwater Rivers (WCR-2014-1723) on November 14, 2014. This action included dredging material in the Snake and Clearwater Rivers at four sites: 1) the downstream navigation lock approach at Ice Harbor Dam, 2) the Federal navigation channel in the Snake and Clearwater Rivers confluence area, 3) the berthing area for the Port of Clarkston, Washington, and 4) the berthing area for the Port of Lewiston, Idaho. The Corps also issued regulatory permits for dredging at commercial ports and berths operated by local port districts or private companies in Clarkston, Washington, and Lewiston, Idaho. Most of these non-Federal navigation areas consisted of arterial channels leading from the main Federal navigation channel to the port or berth, as well as the areas at the port or berth used for loading, unloading, mooring, or turning around. During in-water work, short-term adverse effects on aquatic resources included elevated turbidity, suspension of chemicals, harassment and entrainment of fish, and disruption of benthic organisms that serve as prey for juvenile salmon. The dredged material was disposed of inriver as fill to construct a shallow-water bench for juvenile fish habitat at Knoxway Bench (RM 116) immediately upstream of Knoxway Canyon.

In 2005 to 2006, the Corps deposited approximately 420,000 cubic yards of sand and silt at the upstream end of the Knoxway Bench site. The Corps then shaped the dredged material to create an estimated 3.7-acre shallow-water habitat bench that could be used by juvenile salmonids, particularly juvenile SR fall Chinook salmon. Post-project monitoring for the 2006 effort by the Corps confirmed that juvenile salmonids have been and are using the site for resting and rearing. With the dredging conducted under the 2014 biological opinion, the materials were deposited downstream from the bench created in 2006, and extended riverward of the existing shoreline. The new material formed a uniform, gently sloping shallow-water bench along roughly 2,500 linear feet of shoreline. This feature added approximately 11.4 acres of shallow-water habitat with features preferred for foraging by juvenile salmonids, particularly fall Chinook salmon. In sum, these activities should have little or no negative effect on juvenile or adult SR sockeye salmon, and should increase the amount of available rearing habitat.

2.4.2.1.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of juveniles and adults that are migrating past the dams when these activities are occurring. Although procedures are followed to minimize risks and to rescue fish that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of fish are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Very few adult and juvenile Snake River sockeye salmon have been affected by these activities, because they predominantly migrate from May to July outside of the typical scheduled maintenance period.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult Snake River sockeye salmon has likely resulted in increased passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes have minimized the impacts.

2.4.2.1.5 Adult Migration/Survival

Sockeye salmon adults typically begin arriving at Bonneville Dam in mid-June and migrate upstream during summer when flows are lower and temperatures warmer than we would expect in an undeveloped system. While the upstream migration of adults can be slowed as fish search for fishway entrances and navigate through the fishways themselves, reduced June and July flows could benefit migrating adults by reducing the energetic costs of upstream migration (Rand et al. 2006).

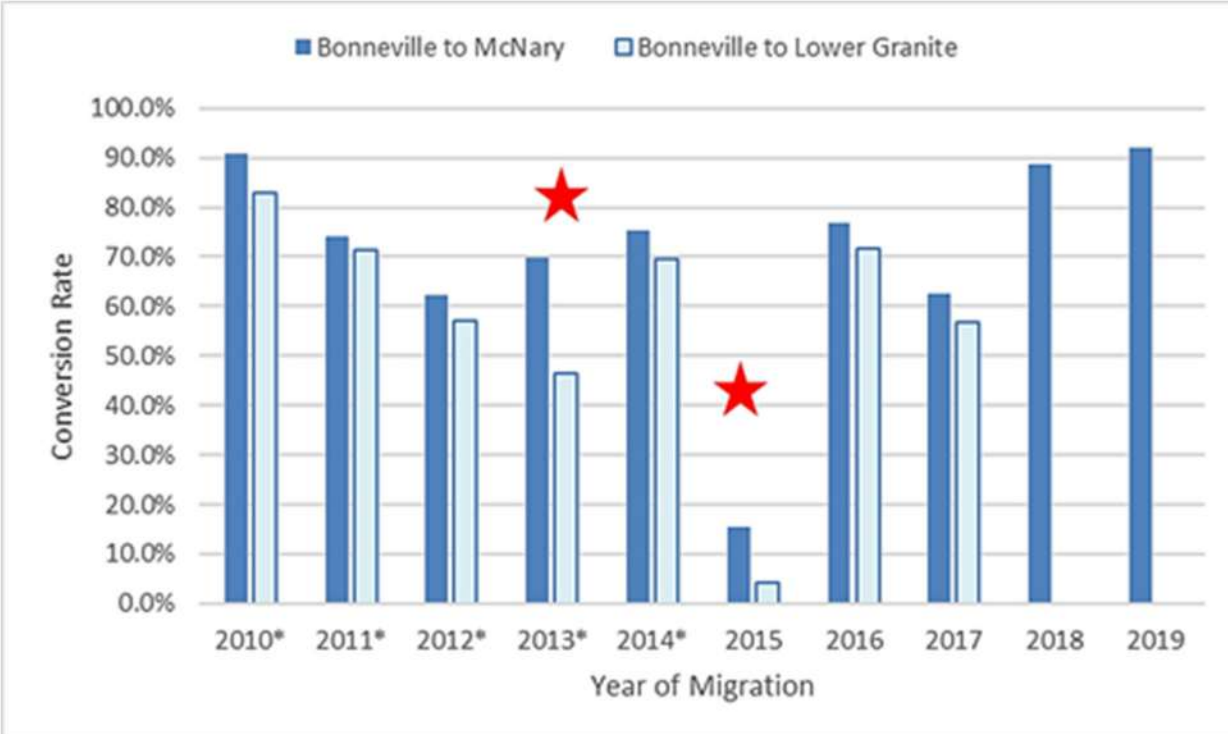

Figure 2.4-5. Recent adult upstream migration survival for SR sockeye salmon. The stars represent years with high water temperatures during the SR sockeye salmon migration period. Not enough PIT-tagged SR sockeye salmon adults returned in 2018 and 2019 to develop an estimate of McNary to Lower Granite Dam survival rates. Upper Columbia River sockeye salmon were used as surrogates to calculate Bonneville to McNary Dam survival in 2018 and 2019.

Recent (2010 to 2019) SR sockeye salmon adult survival rates (Figure 2.4-5) have averaged 70.8 percent from Bonneville to McNary Dam (Upper Columbia River sockeye salmon were used as surrogates in 2018 and 2019). McNary to Lower Granite Dam survival estimates averaged 81.2 percent and Bonneville to Lower Granite survivals averaged 57.4 percent, from 2010 to 2017. Too few PIT tagged SR sockeye salmon were available to estimate adult survival in 2018 and 2019.

These averages include the extremely poor survival year of 2015, when only 15 percent of adult SR sockeye salmon survived from Bonneville to McNary Dam, and only 4 percent survived from Bonneville to Lower Granite Dam (NMFS 2016e).[141] In 2015, low snowpack, coupled with extremely high air temperatures throughout the interior Columbia River basin, resulted in warm water in the major tributaries to the lower Snake and Columbia Rivers. Temperatures in the mainstem Columbia River were the highest recorded from roughly mid-June to mid-July. Adult sockeye salmon, which normally migrate during this period, sustained heavy losses in the Columbia River and tributaries (NMFS 2016b). Excluding 2015, the average adult survival estimate increases to 76.9 percent from Bonneville to McNary Dam (2010 to 2019), 88.8 percent

[141] The average 2008–2016 estimates of adult survival, excluding 2015, are about 77 percent from Bonneville to McNary Dam and 69 percent from Bonneville to Lower Granite Dam (about 7 percent higher).

from McNary to Lower Granite Dam (2010 to 2017) and 65.1 percent from Bonneville to Lower Granite Dam (2010 to 2017).

The most important factor influencing survival for SR sockeye salmon from Lower Granite Dam to spawning areas is temperature. Estimated survival rates for PIT-tagged sockeye salmon show that 73 percent of the adults that passed Lower Granite Dam (2008 to 2012) were recovered at Redfish Lake, the Sawtooth Hatchery weir, or other locations. However, very few fish that pass Lower Granite Dam after the first week in July will survive to reach the Sawtooth Valley due to high temperatures (Crozier et al. 2014).

The greatest challenge for migrating SR sockeye salmon adults is the increasing water temperatures as they move upstream through the hydrosystem. At water temperatures above 64.4°F, sockeye salmon display increases in fallback and straying, and decreases in survival. This is especially true for fish transported as juveniles. From 1999 to 2012, survival of PIT-tagged adult sockeye salmon from Lower Granite Dam to the Sawtooth Valley was negatively correlated ($r^2 = 0.53$) to water temperature in the Snake River (Arthaud and Morrow 2013). When average July water temperatures in the Snake River exceeded 71.6°F (at the Anatone, Washington, gage, upstream of Lower Granite Reservoir), the survival was less than 20 percent, yet survival reached 90 percent as temperatures declined to 64°F. Current efforts to control summer water temperatures in the lower Snake River include regulating outflow temperatures at Dworshak Dam (NMFS 2015c).

SR sockeye salmon experience relatively high rates of fallback at Bonneville, The Dalles, and Lower Granite Dams. Detailed examination of PIT-tag records revealed the existence of fish that may fall back and reascend the same dam many times in a short period, or fall back at multiple dams and then reascend. An increased incidence of fallback events at these dams tends to be associated with water temperatures in excess of 71.6°F, and may be related to temperature stress and the failure of homing behavior. Some of the unaccounted for losses of SR sockeye salmon adults could be related to fish that fall back but fail to reascend the dams (with the current PIT-tag detection systems, only fish that reascend the fish ladder after falling back over the dam can be detected). Fish transported as juveniles were more likely to fall back than inriver migrants at Bonneville, The Dalles, and McNary Dams, but not at the lower Snake River dams. Fish also had a higher fallback rate if they had fallen back at previous dams (Crozier et al. 2018).

Extremely high rates of fallback have been observed at Lower Granite Dam in some years, possibly associated with high forebay temperatures. In addition, temperature differentials between the entrance and exit of adult fish ladders was shown to delay passage of adult steelhead and Chinook salmon in the Lower Snake River (Caudill et al. 2013). Caudill et al. (2013) noted that the related increases in travel time and thermal exposure, and related physiological stresses could reduce successful migration of salmon and steelhead to natal tributaries. Fish ladder–cooling structures that pump colder water from deeper in the reservoir into the fish ladder to reduce ladder temperature differentials have been installed at Little Goose and Lower Granite Dams. The cooling device at Lower Granite Dam likely contributed to lower fallback rates in

2016 to 2017. The cooling structure at Little Goose Dam fishway exit began operating in 2018. Mechanical issues related to the pump resulted in some short-term outages in 2018, but these issues have been addressed and this structure is likely to continue to improve passage conditions for adult sockeye salmon at Little Goose Dam. There are currently no structures to reduce ladder temperatures at the other CRS dams, but research has identified that during the warmest months, cooler water is available that could be pumped into ladder exits to reduce high temperatures and ladder differentials (Lundell 2019).

SR sockeye salmon have relatively low survival though the Bonneville to McNary Dam reach (Figure 2.4-5 and 2.4-6), with their survival rate slightly lower than the rate for Upper Columbia River sockeye salmon, which migrate through the reach at the same time. However, when the data for fish that were transported are separated from the data for fish that migrated inriver as juveniles, the inriver migrants show survival rates similar to Upper Columbia River sockeye salmon, while transported SR sockeye salmon have lower survival rates. Survival for both transported fish and inriver migrants improves after they enter the Snake River, and declines again from Lower Granite Dam to the Sawtooth Valley (Figure 2.4-6) (NMFS 2016a, b). About 43 percent of sockeye have been transported on average (range of 8 to 58 percent, as described in Section 2.4.2.1.7, below) and the transport rate is expected to decrease substantially with the proposed higher spill levels. An earlier start to transport would not substantially increase the numbers of SR sockeye smolts collected because only about 5 to 10 percent of SR sockeye smolts have arrived at Lower Granite by the first week of May in a typical year.[142]

[142] On average (2010 to 2019) about 7 percent of the annual outmigration for SR sockeye smolts had arrived at Lower Granite Dam by May 1, whereas 50 percent of SR spring/summer Chinook salmon and SRB steelhead arrived by May 2 (DART 2020j).

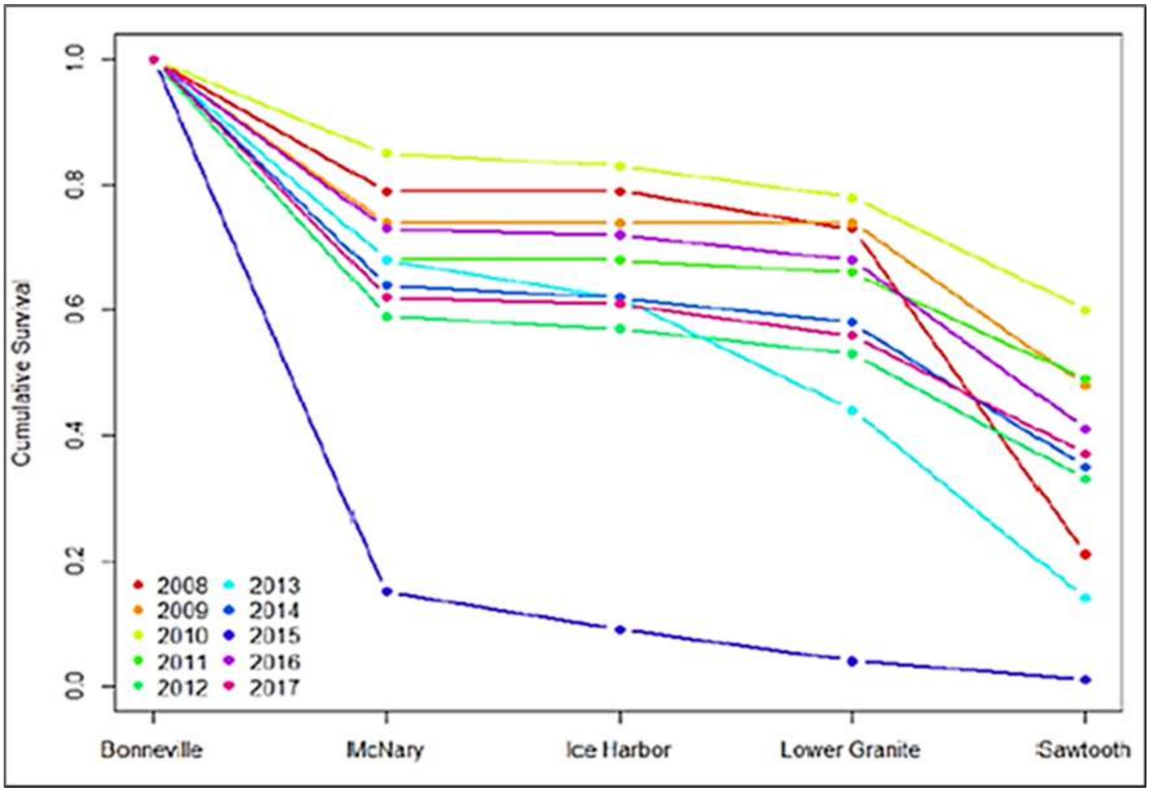

Figure 2.4-6. Observed cumulative survival for adult SR sockeye salmon from Bonneville Dam to the Sawtooth Valley.

Crozier et al. (2014) reviewed PIT-tag data from 2008 to 2013 and developed statistical models to identify factors associated with upstream migration survival and the strength of their effects. They found that the most important predictors of survival across reaches and years were thermal exposure and fish travel time, which are both influenced by fallback rates. Fallback for migrating adults is a particular concern for SR sockeye salmon because this ESU appears to fall back more than other species; as discussed above, fallback rates are significantly higher for adults that were transported as juveniles, although this effect varies from year to year (Crozier et al. 2014). Fallback is also influenced by temperature, flow, TDG, and downstream migration history (inriver, or transport). There is also the potential for unreported harvest, or estimation methods for harvest, to contribute to the lower adult sockeye salmon survival rate estimates through the lower Columbia River (compared to the Snake River) (NMFS 2014a). It is also possible that interaction effects between the temperature, hydrosystem operations, harvest, and potentially other factors are affecting adult survival rates in this reach.

2.4.2.1.6 Juvenile Migration and/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and non-native species that are predators, competitors, or food sources for migrating juvenile sockeye salmon. Travel times of migrating smolts increase as they pass through the reservoirs (compared to a free-flowing river), increasing exposure to both native and nonnative predators (see predation section below), and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spillbays, or surface passage routes) (NMFS 2008a).

However, overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1992, when the species was listed. This is most likely the result of improved structures and operations and predator-management programs at the Corps' mainstem projects (24-hour volitional spill, surface passage routes, improved juvenile bypass systems, predator-management measures, etc.) (NMFS 2017e).

Table 2.4-6 depicts the Fish Operations Plan (FOP) for spring spill during 2017 through 2020. There was a substantial increase in spill over the dam spillways in the spring during 2018 in response to a court order requiring additional spill and in 2019 and 2020 under the Flexible Spill Agreement. Spill, as a percentage of flow at Snake River dams, averaged 37.2 percent in 2018, with daily mean spill percentages above the long-term spill average (1993 to 2018) for nearly the entire migration period. In the spring of 2019, during the 120 percent flexible spring spill operation, mean discharge in the Snake River was high at 45.5 kcfs, which was above the 2006 to 2019 mean of 34.3 kcfs. In 2019, spill averaged 38.5 percent at the Snake River dams, which was above the long-term mean of 34.6 percent, but lower than what would be expected with flexible spill during low and moderate flow years.

Table 2.4-6. Summary of 2017, 2018, 2019, and 2020 Fish Operations Plan spring spill levels at lower Snake River and Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flexible Spill	2020 Flexible Spill
Lower Granite	20 kcfs/20 kcfs	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 20 kcfs Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 20 kcfs Performance Standard (8 hours per day)
Little Goose	30%/30%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)
Lower Monumental	Gas Cap/Gas Cap (approximate Gas Cap range: 20–29 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (uniform spill pattern, 16 hours per day) / 30 kcfs Performance Standard (bulk spill pattern, 8 hours per day)	125% TDG gas cap (uniform spill pattern, 16 hours per day) / 30 kcfs Performance Standard (bulk spill pattern, 8 hours per day)
Ice Harbor	**April 3-April 28:** 45 kcfs/Gas Cap **April 28-June 20:** 30%/30% vs. 45 kcfs/Gas Cap	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flexible Spill	2020 Flexible Spill
	(approximate Gas Cap range: 75–95 kcfs)			
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)
John Day	**April 10–April 28:** 30%/30% **April 28–June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 40% Performance Standard (8 hours per day)	40%/40%
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)	120% TDG gas cap (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)	125% TDG gas cap up to 150 kcfs (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)

[1] Spill operations are described as percent of project outflow or kcfs.

A juvenile survival estimate could not be made downstream of McNary Dam in 2011 because too few fish were detected at, and downstream of, Bonneville Dam. As noted later, in Section 2.4.2.2, juvenile survival estimates from Lower Granite to Bonneville Dam from 2015 to 2017 were substantially impacted by issues relating to the rearing and transport of Springfield Hatchery smolts (which made up the great majority of PIT-tagged fish used to make survival estimates). Survival rates in these years ranged from about 12 to 37 percent, but the rates are not considered estimates of juvenile survival because they were strongly affected by the compromised condition of the test fish due to the hard water issues with Springfield Hatchery. The 2018 and 2019 survival estimates include hatchery fish that were raised at Springfield Hatchery after water quality improvements were made. A gas cap spill program was implemented in the spring of 2018 and a 120 percent Flexible Spill operation was implemented in 2019. Lower Granite to Bonneville Dam juvenile survival estimates in 2018 and 2019 were estimated to be 64.3 percent and 43.4 percent, respectively. The average to above-average survival rates in 2018 and 2019 indicate that the recent improvements in hatchery rearing and transport practices have likely addressed the problems related to the lower rates in 2015 to 2017.

Survival estimates for juvenile SR sockeye salmon migrants (Widener et al. 2020, Zabel 2019; Figure 2.4-7) are summarized below:

- Juvenile survival estimates from Lower Granite to McNary Dam (2009 to 2019, excluding 2015 to 2017) averaged over 74 percent, ranging from about 66 to 87 percent. Juvenile survival estimates from Lower Granite to Bonneville Dam (2009 to 2019, excluding 2015 to 2017) averaged nearly 56 percent, ranging from about 43 to 71 percent This represents a substantial improvement in survival, due to improved structures and operations, compared to 1998 to 2003 estimates from Lower Granite to Bonneville Dam, which averaged only about 28 percent.
- Survival estimates from Lower Granite to McNary and Bonneville Dams during gas cap spill in 2018 were 68 and 64 percent, respectively; slightly higher than average in the Lower Granite to McNary Dam reach, and the second highest since 2010 in the longer, Lower Granite to Bonneville Dam reach, the highest being 71 percent in 2014.
- Preliminary survival estimates from Lower Granite to McNary and Bonneville Dams during the 120 percent Flexible Spill operation in 2019 were 84 percent and 43 percent, respectively; substantially higher than average (74 percent) in the Lower Granite to McNary reach, but substantially lower than average (56 percent) in the longer, Lower Granite to Bonneville Dam reach. It is too early to determine if this pattern will continue.

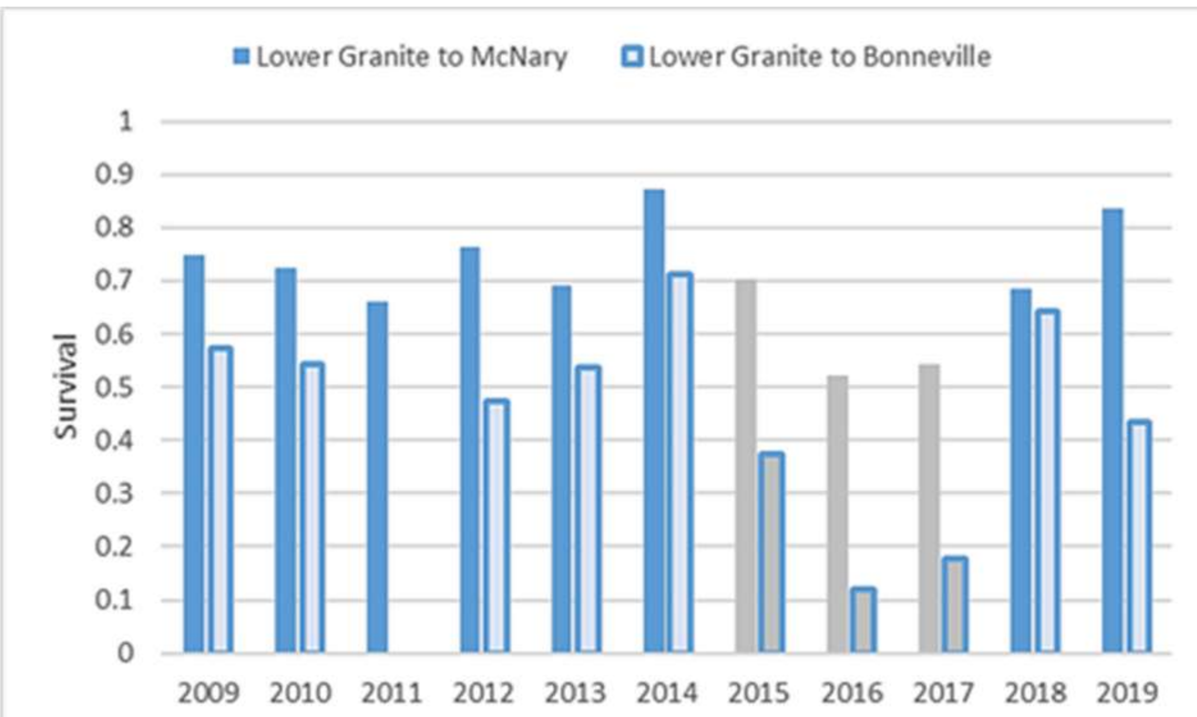

Figure 2.4-7. Juvenile SR sockeye salmon survival rates from Lower Granite to McNary and Bonneville Dams (2008 to 2014). The years 2015-2017 are represented by gray to indicate years when issues with hatchery water supplies resulted in the release of poor condition smolts. Source: Zabel 2019 and Widener et al. 2020.

2.4.2.1.7 Transportation

Juvenile fish transport has been used for mitigation in the CRS since 1981 (Baxter et al. 1996). The goal of transportation is to avoid mortality directly caused by migration past dams and thus to increase the number of fish that return as adults. Turbine intake screens, part of the juvenile bypass systems,[143] divert smolts away from turbine units and into a system of channels and flumes before bypassing them into the tailrace below the dam or collecting them in raceways where they can be loaded onto barges or trucks, transported below Bonneville Dam, and then released into the lower Columbia River to continue migrating to the ocean. Dams currently used for collection are Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam. SR sockeye salmon smolts were transported from McNary Dam from 1985 to 2012, after which all transport from McNary Dam ceased based on a recommendation from NMFS.

The effectiveness of the transportation program is evaluated annually. After the initiation of transportation, nearly all collected fish from the run-at-large are transported. However, the detection and collection system allows for a portion of PIT-tagged fish to continue to be bypassed. This allows assessment of transportation by comparing survival rates of transported and bypassed fish. Unfortunately, for SR sockeye salmon, there are far fewer data available to assess the efficacy of transportation, compared to Chinook salmon and steelhead. Far fewer PIT-tagged sockeye smolts have been released upstream of Lower Granite Dam, and total adult counts available in annual transported or bypassed groups rarely exceed 20, and are often fewer than 10.

The primary metrics for assessing transport apply ratios of SAR rates for transported fish relative to SARs for fish that remained inriver and passed through the hydrosystem by other routes during migration. Several types of ratios are useful, differing by which inriver fish are included in the ratio. This document uses two main types of transport ratio to describe effects of transport on adult returns. These ratios are described below:

1. Transport-in-River Ratio (TIR): The TIR is the ratio of the SAR of fish transported from Lower Granite, Little Goose, or Lower Monumental Dams, relative to the SAR of fish that never entered a collection system at these dams. PIT-tagged fish used for TIR estimates come only from fish tagged upstream of Lower Granite Dam, and estimates of smolt abundance are adjusted to account for mortality between Lower Granite Dam and the downstream transport site. The Comparative Survival Study (CSS) uses this metric to report transport results.
2. Transport-Bypass Ratio (T:B): The T:B is the ratio of the SAR of fish transported from a specific collector project, relative to the SAR of fish that entered the same collection system and were then bypassed to the river downstream. The NWFSC generally uses this metric to report transport results.

Both of these ratios are used to describe adult return rates to Lower Granite Dam and sometimes to other projects (e.g., Bonneville Dam). T:B and TIR greater than one indicate that transported fish returned as adults to Lower Granite Dam at higher rates than corresponding bypassed or

[143] Almost all powerhouses at the eight CRS mainstem dams have juvenile bypass systems. The exceptions are The Dalles Dam and Powerhouse 1 at Bonneville Dam.

inriver fish. T:B and TIR less than one indicate that transported fish returned as adults at lower rates than corresponding bypassed or inriver fish. Because the two ratios compare effects of transportation to effects of different passage routes, they can address different management questions. The T:B provides direct evidence regarding the alternative management options for fish that enter the juvenile bypass system at a collector dam. A T:B greater than one indicates that, among the subset of fish that entered the powerhouse and were diverted into the bypass system, transported fish had higher SARs than bypassed fish. The TIR provides a different perspective, by comparing SARs for transported fish to those for fish that never entered a bypass system at a Snake River collector project. These inriver fish passed all collector dams via spillways or turbines. A TIR less than one suggests that management options should focus on decreasing the total number of fish entering the powerhouse.

For the species with higher sample sizes informing analysis (SR spring/summer Chinook salmon and SRB steelhead), data from PIT-tagged fish have shown that fish that are bypassed at one or more collector dams generally have lower SARs than inriver fish that pass without ever encountering a bypass system. The majority of these never-detected fish pass dams via spillways, with a minority passing via turbines. Thus T:B estimates tend to exceed corresponding TIR estimates. In this sense, TIR represents a higher standard by which to assess the efficacy of transportation. Both measures have merits and are best viewed collectively. An advantage of T:B is that data on transport effects can be evaluated on a finer temporal scale than is possible with TIR. Each PIT-tagged fish that enters the bypass system is detected. Thus, the date on which the fish was transported or bypassed is known, and date-specific T:Bs can be estimated. Fish that pass through spillway or turbine routes are not detected, and thus have an unknown passage date, which means that TIR can be estimated only on an annual scale.[144]

Both the NWFSC and the Fish Passage Center (FPC) have estimated the percentage of SR sockeye salmon transported for recent smolt migration years (2013 to 2019 for the NWFSC, 2013 to 2018 for the FPC). The NWFSC estimates have averaged 43 percent (range of 26 to 51 percent) for natural-origin and hatchery-origin smolts combined. The Fish Passage Center estimates have averaged 41 percent (range of 8 to 58 percent) for natural-origin and hatchery-origin smolts combined (DeHart 2018).

Small sample sizes of SR sockeye salmon, coupled with interannual variability, have made it difficult to determine with certainty the effects of transportation. There were sufficient numbers of SR sockeye salmon smolts PIT tagged in 2009 and 2011 to 2014 to estimate the benefit of sockeye transportation. Based on these years, the average rate of return to Bonneville Dam for adults that were transported as smolts from Lower Granite Dam was more than twice that of smolts that were bypassed (geometric mean T:B = 2.40). However, T:B was lower when measured for adults returning to Lower Granite Dam (geometric mean T:B = 1.40). This indicates that adults that had been transported as juveniles were less likely than those bypassed

[144] A PIT-tag detection system has been installed in one spillbay at Lower Granite Dam, and will be used for the first time in smolt migration year 2020. This will be the first time that a passage route other than a juvenile bypass system has been monitored.

as juveniles to successfully migrate upstream from Bonneville Dam to Lower Granite Dam. Fallback of transported fish contributes to lower survival in the Lower Columbia River reaches; Crozier et al. (2015) found that adults that had been transported as juveniles were almost three times as likely to fall back at Bonneville, The Dalles, and McNary Dams compared to those that had migrated inriver as juveniles.

SR sockeye juveniles begin arriving at the three collector dams in early April. Since 2006, fisheries managers have chosen not to transport fish in the run-at-large for the first three or four weeks of April; fish that enter the juvenile bypass system are exclusively bypassed during this early period. This choice was based on temporal T:B data from prior years that showed no benefit for spring-migrating yearling Chinook salmon or steelhead transported early in the season. The same data set showed that later in the season, starting in late April or early May, transportation resulted in higher SARs than bypassing. Thus, since 2006 managers generally have chosen to initiate transportation around May 1st. However, transport began on April 23 in 2018 and April 24 in 2019 and 2020.

While the overall result of transportation has been generally positive for SR sockeye salmon, in the form of rates of survival to adulthood, smolt transportation is not a panacea (Williams et al. 2005). Informally, a regional goal is for survival of inriver migrants to meet or exceed that observed for transported fish. That goal has not yet been met for spring migrants, but survival rates for transported fish provide an important benchmark. The alternative to transportation is to improve inriver migration conditions to the point where transportation provides little benefit. Over the last several decades various transportation strategies have been proposed and have been reviewed by the ISAB, most recently in 2010 (ISAB 2010). The guidance provided by the ISAB has been consistent, which is to “spread the risk” between transport and inriver passage, and to measure the effects of inriver survival and transportation over time. The T:B and TIR ratios provide the information necessary to measure these effects.

Since 2006, efforts to improve conditions for smolts migrating inriver have included the provision of 24-hour spill during juvenile migration at all of the mainstem projects, the addition of surface passage structures, and the relocation of juvenile bypass outfall locations to improve inriver survival of bypassed fish. The most recent change was the implementation of the Flexible Spill Agreement, which as of spring 2020 had increased spring spill levels up to a 125 percent TDG tailrace standard (16 hours per day) at the Snake River projects and McNary Dam (NMFS 2019a).

While higher spill is anticipated to result in fewer smolts at a project being bypassed and collected for transport, that effect would not be uniform under all flow conditions. At a given spill level, more fish will pass via spill under low-flow conditions. When inriver conditions are poor due to low flows and high water temperatures, as occurred in 2015, in-season management decisions must weigh the potentially large benefits of increasing the proportion of fish transported against the general desire to improve inriver conditions, with spill as the main strategy identified to date.

In general, determining an "optimum" transport operation is challenging for several reasons. The benefit of transportation varies seasonally, by river flow and temperature conditions, by collector dam, and likely also because of differing ocean conditions at the time of ocean entry for transported and inriver migrants. Seasonal patterns in the SARS of transported and inriver migrants also vary by species and rearing type.

In addition, transport has unintended consequences. Handling and transport of juveniles results in their being held at much higher densities than observed in the wild, increasing the risk of disease transmission. Also, because it takes inriver migrating fish several weeks (or months, for those adopting the yearling life history strategy) to travel from the lower Snake River to Bonneville Dam, and they are growing during that period, inriver migrants are larger and enter the Columbia River estuary and plume later in time than transported fish. Smaller size at ocean entry is associated with reduced survival (NMFS 2014a). These factors, in some combination, likely contribute to the sometimes observed higher mortality for transported fish after being released from barges compared to inriver migrating smolts as evidenced by adult returns to Bonneville Dam (NMFS 2008a).

Another unintended consequence of transportation is increased straying of returning adults (Keefer and Caudill 2014). Smolts that migrate inriver take 2 weeks or longer to travel from Lower Granite Dam to Bonneville Dam, imprinting on the varying water chemistry of tributaries as they go. Smolts transported in barges follow the course of the river, but they make the trip in 2 to 3 days. It appears that the reduced transit time prevents fish in barges from acquiring waypoints along the migration route as effectively, and this can result in less directed upstream migration for returning adults. This increases travel time and likely results in increased exposure to warm water temperature in the late summer and increased exposure to lower Columbia River fisheries. Returning steelhead that were transported as smolts had lower homing behavior, higher unaccounted-for losses, and higher straying rates than inriver migrants (Keefer et al. 2008). Analogous studies for SR sockeye are not available, but it is likely that transported sockeye stray at rates higher than smolts that migrate inriver.

The SARs presented in this document are based on adults counted at Lower Granite Dam. Thus, losses of transported fish resulting from straying are accounted for, and TIR and T:B estimates still show a general benefit of transport. Uncertainty remains about whether alteration of adult-homing behavior has important consequences for fitness after adults successfully pass Lower Granite Dam.

Adult Emergency Transportation

High temperatures contributed substantially to high adult mortalities in 2013 and 2015. SR sockeye salmon, especially those that were previously transported as juveniles, were harmed disproportionately by high temperatures in the Bonneville Dam to McNary Dam reach in 2015 compared to unlisted sockeye salmon from upstream Columbia River tributaries (NMFS 2016a). To address high temperatures in the Salmon River in 2015, NMFS authorized the IDFG to trap some adult SR sockeye salmon at Lower Granite Dam and transport them to their hatchery facility in Eagle, Idaho. Nearly all of these transported adults survived and contributed to the 2015 brood-year production. Ultimately, 35 of the 91 fish (38 percent) that were spawned in 2015 were captured and transported from Lower Granite Dam (NMFS 2016a).

2.4.2.2 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Since the ESA listing of SR sockeye salmon in 1991, a partnership of state, tribal, and Federal fish managers has operated a captive broodstock hatchery program to save the Redfish Lake sockeye salmon population; NMFS described the effects of this program in a biological opinion (NMFS 2013c). Between 1991 and 1998, all 16 of the natural-origin adult sockeye salmon that returned to the weir at Redfish Lake were incorporated into the captive broodstock program, as well as outmigrating smolts captured between 1991 and 1993, and residual sockeye salmon captured between 1992 and 1995. The program has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and has produced several million eggs and juveniles, as well as several thousand adults, for release into the wild. Fish rearing at each facility is conducted at low density in tanks in bio-secure buildings.

Approximately two-thirds of the adults captured in recent years for the captive broodstock program were taken at the Redfish Lake Creek weir; the remaining adults were captured at the Sawtooth Hatchery weir on the mainstem Salmon River upstream of the Redfish Lake Creek confluence. The hatchery program's priority is genetic conservation and building sufficient returns to support sustained outplanting (NMFS 2013c, 2015c). While 318 returning anadromous adults have been released into Redfish and Pettit lakes since the most recent status review, the captive broodstock program provides the majority of the volitional spawners outplanted into Redfish and Pettit lakes. While the program is beginning to transition into Phase 2 (population re-colonization phase) of the three-phased approach now that Springfield hatchery is in full production and water chemistry issues have been resolved, the goals of Phase 1 remain an important component of the hatchery program (NMFS 2013c).

The number of SR sockeye salmon outmigrants continued to increase through 2017 (Johnson et al. 2017). However, hatchery production was switched from the Oxbow and Sawtooth Hatcheries to Springfield Hatchery in 2014. As previously mentioned, survival of the 2015 to 2017 hatchery releases during migration from Lower Granite to Bonneville Dam ranged from 12 to 37 percent, compared with the 2009 to 2014 average of 54 percent (Widener et al. 2018). Survival from release to Lower Granite Dam was also affected, ranging from 20 to 30 percent when releases from Oxbow and Sawtooth Hatcheries typically exceeded 50 percent. After investigating the potential causes for the reduced survival, IDFG determined that the new hatchery site had much harder water (234 mg/l of calcium) than the original Sawtooth Hatchery site and the release locations (11 to 68 mg/l of calcium) (Trushenski et al. 2019). This caused stress in the juveniles when they were directly released into Redfish Lake Creek. Several mitigation strategies for addressing the water chemistry differences were tested, and the most biologically and logistically effective strategy was determined to be stepwise acclimation from high-to medium-hardness water and then from medium- to low-hardness water. Fish acclimated in this manner survived to Lower Granite Dam at a rate of 69 to 75 percent, while smolts directly released into Redfish Lake Creek survived at only 18 percent (Trushenski et al. 2019).

2.4.2.3 Recent Ocean and Lower River Harvest

Few SR sockeye salmon are caught in ocean fisheries, and ocean-fishing mortality on SR sockeye salmon is assumed to be zero (NMFS 2018a). Non-Indian fisheries in the Columbia River mainstem below the Highway 395 Bridge, which crosses the Columbia River between Kennewick and Pasco, Washington, are limited to a harvest rate of 1 percent and Treaty Indian fisheries to 5 to 7 percent, depending on the run size of upriver sockeye salmon stocks. NMFS' recently completed biological opinion on the 2018 to 2027 *U.S. v. Oregon* Management Agreement concluded that the effects of harvest on SR sockeye salmon, when considering the current reliance on hatchery programs, will allow continued gains in viability scores.

The migration behavior of SR sockeye salmon makes them less vulnerable to harvest impacts than other Columbia River basin sockeye salmon stocks. Their migration period is slightly later, though it overlaps the migration of the Upper Columbia sockeye salmon run and also coincides with the more heavily exploited summer Chinook salmon harvest season. SR sockeye salmon also migrate through the system in a relatively short period, with 80 percent of the run passing Bonneville in 17 to 28 days. The timing of 3- to 4-day gillnet openings has a potentially limited impact on SR sockeye salmon returns as the mesh size they use is large enough to generally allow the smaller-sized sockeye salmon to pass through them while targeting larger-bodied Chinook salmon. However, the slightly later run timing of SR sockeye salmon makes them vulnerable to late season openings, a management strategy frequently employed when initial run size estimates were too low or harvest rates were lower than expected, so there is a large remaining catch quota at the end of the season.

While reported harvest estimates are consistently below the 8 percent limit for SR sockeye salmon, PIT-tag-based adult survival estimates indicate that losses between Bonneville and McNary Dams (three dams and reservoirs) are substantial (averaging about 40 percent)—much higher than the losses estimated between McNary and Lower Granite Dams (four dams and reservoirs), which are generally less than 10 percent. Other potential causes of mortality, fallback and straying (Crozier et al. 2014), have been examined and do not appear to occur at a high enough rate to account for the extra mortality in this reach. In years when lower Columbia River water temperatures have exceeded 64.4°F, primarily 2013 and 2015, there have been indications of mortality due to disease and stress caused by high temperatures, but there is little or no indication of the source of mortality in other years. Other factors, such as lower Columbia River hydropower operations, unknown effects of harvest, unreported harvest, unknown biological factors (diseases or parasites), or a combination of these factors, have been hypothesized as potential mechanisms to explain these losses.

Harvest managers continue to evaluate this issue (lower observed PIT-tag survival rates in the lower Columbia River for SR sockeye salmon) within the *U.S. v. Oregon* Technical Advisory Committee.

2.4.2.4 Tributary Habitat

Historically, sockeye salmon ascended the Snake River to the Wallowa River basin in northeastern Oregon and the Payette and Salmon River basins in Idaho to spawn in natural lakes. Today, the last remaining SR sockeye salmon spawn in the Sawtooth Valley, in the Salmon River Basin of Idaho. The following subsections describe environmental baseline conditions in the natal lakes in the Sawtooth Valley, as well as conditions in the Salmon River migration corridor.

2.4.2.4.1 Natal Lakes in the Sawtooth Valley

Five lakes in the Sawtooth Valley historically supported anadromous sockeye salmon: Alturas, Pettit, Redfish, Stanley, and Yellowbelly Lakes. Currently, only the Redfish Lake population (supported by a captive broodstock program) is considered extant, although reintroduction efforts have been ongoing in Redfish Lake since 1993, Pettit Lake since 1995, and Alturas Lake since 1997, with Redfish Lake stock. All five lakes lie within the Sawtooth National Recreation Area and much of the headwaters of each drainage are designated as wilderness. Overall, habitat conditions for SR sockeye salmon in these high mountain lakes remain excellent, but access to the habitats remains an issue (NMFS 2015c).

When SR sockeye salmon were originally listed in 1991, NMFS noted that the greatest tributary habitat issue facing the ESU was lack of physical access to any of the historical spawning areas except Redfish Lake, because the diminished spatial structure increased risk due to catastrophic events and limited opportunities for establishing a locally adapted, naturally spawning population (NMFS 2015c). Since then, barriers on Alturas, Pettit, and Yellowbelly Lakes have been either modified or removed. To improve spatial distribution, pre-smolt outplants into Redfish, Alturas, and Pettit Lakes were initiated in the mid-1990s. Currently, however, adult returns are still precluded from Alturas, Pettit, and Yellowbelly Lakes by the Sawtooth Fish Hatchery weir and from Stanley Lake by the fish barrier at the lake outlet. Plans are in place, and have begun being implemented, to allow sockeye salmon adults to return to their lake of origin by trapping adults at the Sawtooth Hatchery weir and transporting them to Alturas or Pettit Lake or, alternatively, to pass the adults to allow for volitional migration (NMFS 2015c).[145]

Overall habitat conditions in each of the natal lakes are briefly described below:

- Redfish Lake: Most of the Redfish Lake watershed remains in near natural condition, and much of the lake shore is undeveloped and unaffected by upstream watershed activities in the Sawtooth National Recreation Area. Water quality in the lake is generally considered to provide suitable rearing habitat for juvenile sockeye salmon. Developed recreation sites and/or commercial activities occupy approximately 2 miles of shoreline on the north end of the lake and may result in elevated sediments, but determining any impacts on fish habitat would require further monitoring. Recreational development on the north end of the lake and seasonal motorized boating has also likely released some chemical pollutants. Some conditions have been addressed (e.g., gas storage at the marina); however, with existing development, the potential for pollutant threats remains. The U.S. Forest Service has also implemented several projects to remove lakeshore trails, encourage recovery of shoreline vegetation, and improve lake and shoreline habitat conditions by moving campsites away from spawning areas. Decades of fire suppression have also allowed most of the surrounding forest to reach late seral stage, and many mature lodgepole pines are now standing dead because of a natural infestation of mountain pine beetle. The U.S. Forest Service is reducing the accumulated risk of catastrophic fires by thinning trees, conducting prescribed burns, and removing surface fuels (fallen branches, low flammable brush, and other flammable understory vegetation) (NMFS 2015c).
- Stanley Lake: U.S. Forest Service assessments have concluded that the Stanley Lake watershed has high-quality habitat conditions and integrity, with some areas of low integrity along the lakeshore. Past intensive uses include mining in the 1990s, including within some sensitive streamside and lakeside areas. The main access road was upgraded in the 1930s with long segments located next to Stanley Lake Creek. Intensive sheep and cattle grazing occurred within the watershed until 1993. Timber harvest, including road building, occurred in parts of the watershed in the 1960s. Campground and boat launch developments also affect some habitat areas. Overall watershed conditions are considered to be good and improving, although some concerns exist about shoreline impacts from recreational use (NMFS 2015c).

[145] Since 2014, IDFG has released a small number of captive-reared adults into Pettit Lake for reintroduction efforts (Kozfkay 2018, email from Furfey to Krasnow dated September 4, 2018). IDFG also screens any natural-origin fish trapped at the Sawtooth Hatchery weir to determine if they originate from Pettit or Alturas Lake and releases them into the appropriate lake upon genetic confirmation. The agency plans to evaluate whether smolt production has increased as a result of those releases. This will inform future actions for Pettit Lake and help determine whether the program can continue to release captive adults at current levels (or increase release numbers) or should focus on Redfish Lake.

- Yellowbelly Lake: Few management activities occur within the Yellowbelly Lake watershed, and habitat conditions are considered nearly pristine. Recreational use on public land and minor development on private land near the mouth of the lake have had only a small influence within the watershed. IDFG management of the lake through a former fish barrier and chemical treatments has had the greatest influence on fish (NMFS 2015c).
- Pettit Lake: Other than lakeshore developments (recreation and cabin lots) that occupy nearly 50 percent of the shoreline, there is little land use disturbance in the watershed. However, it is possible that historical sockeye salmon spawning habitats are adjacent to these lakeside developments. Condition assessments by the U.S. Forest Service in 2006 showed that the shoreline in these areas had more trampled banks and less vegetation or woody debris than undeveloped shoreline. Overall, watershed conditions are functioning appropriately and habitat conditions are nearly pristine (NMFS 2015c).
- Alturas Lake: Habitat in the Alturas Lake watershed is in relatively good condition, although there have been some impacts. In the past, irrigation diversions, including one on Alturas Lake Creek, significantly affected stream flow and fish passage into the lake. During the core of the summer irrigation season, natural flows were less than the appropriated flows such that, prior to 1992, Alturas Lake Creek was routinely dewatered. Even when not fully dewatered, the diversion structure itself precluded or impaired upstream migration. In 1997, the last private irrigator discontinued use, and the U.S. Forest Service has since removed the former diversion structure and restored natural channel conditions. Historical legacy effects of grazing and mining in the headwaters have exacerbated sediment loading impacts in Alturas Lake, and about 60 percent of historical spawning habitat is adjacent to recreation sites that occupy about 1 mile of shoreline. The U.S. Forest Service has addressed some of these impacts. More than 5 miles of roads have been closed and rehabilitated, and visitor facilities have been altered to reduce streamside pressure. As natural recovery of these areas proceeds, habitat conditions are expected to continue to improve (NMFS 2015c).

2.4.2.4.2 Salmon River Migration Corridor

The Salmon River flows 410 miles through central Idaho to join the Snake River in lower Hells Canyon and represents almost half of the SR sockeye salmon migration route. Juvenile sockeye salmon migrants move quickly through this reach after leaving their natal lakes in late spring and early summer, arriving at Lower Granite Dam in about 7 days. Adults migrate upstream in late summer, spending more than 30 days traveling up the Salmon River and returning to the Sawtooth Valley lakes in August and September (NMFS 2015c).

Much of the upper Salmon basin is managed for public use, with some areas in wilderness or roadless areas. High watershed and aquatic integrity is found in the Upper Middle Fork, Lower Middle Fork, and Middle Salmon–Chamberlain watersheds. Habitats tend to be more modified or degraded in broad valleys with easier access for humans and development such as the Little Salmon, lower Salmon, Pahsimeroi, and Lemhi River watersheds. Much of the subbasin is managed by the U.S. Forest Service or Bureau of Land Management for multiple uses (NMFS 2015c).

Private lands tend to be concentrated along the valley bottoms near the Salmon River. Small towns in the subbasin (Stanley, Challis, Salmon, Riggins, New Meadows, and White Bird) also are located along the river, with rural populations in the surrounding areas. The town of Salmon is the largest, with slightly more than 3,000 people; most towns have under 500 residents (NPCC 2004a). Cattle ranching and agriculture are the main economic activities. Irrigation diversions are common and have contributed to low summer flows in the past; however, restoration efforts are now reducing impacts on sockeye salmon from irrigation water withdrawals and diversion structures in some areas. Logging and mining were important activities historically, but have declined since the 1990s. Water quality is affected by land uses that include livestock grazing, road construction, irrigation withdrawals, logging, and mining. New road construction and other development is occurring in some areas, causing stream erosion and sediment input to streams (NMFS 2015c).

Despite the relatively sparse human population and expanse of public lands, both juvenile and adult sockeye salmon experience unexplained mortality in the Salmon River migration corridor (NMFS 2015c). For juvenile sockeye salmon migrating from the Sawtooth Valley to Lower Granite Dam, the great majority of juvenile mortality is incurred upstream of Lower Granite Reservoir (Axel et al. 2013, 2014). Estimated survival of hatchery juveniles in the reach has been highly variable. The survival of Sawtooth (2010 to 2015) and Springfield (2016 to 2018) Hatchery-reared fish released at Redfish Lake Creek Trap averaged nearly 48 percent, ranging from 16 percent in 2010 and 2017 to 79 percent in 2012 (Faulkner et al. 2011, 2012, 2013a, 2013b, 2015, 2016, 2017; Widener et al. 2018, 2019, 2020). Excluding 2017, a year when the survival of Springfield Hatchery release juveniles was negatively impacted by previously described hard water issues, the average survival rate increases to nearly 55 percent.

Predation could be responsible for much of the juvenile mortality in the upper Salmon River. In 2013, researchers watched common mergansers (*Mergus merganser*), osprey (*Pandion haliaetus*), double-crested cormorants (*Phalacrocorax auritus*), and western grebe (*Aechmophorus occidentalis*) feeding in Little Redfish Lake below their release site as study fish moved through the area. Bull trout (*Salvelinus confluentus*) also chased schools of juvenile sockeye salmon as they moved through Little Redfish Lake (Axel et al. 2014). Adult migrants are also lost in the Salmon River corridor (Keefer et al. 2008). Adult sockeye salmon return to the Salmon River in late summer, when flows often reach low levels and water temperatures peak. Summer flow reductions in the Salmon River basin could impair upstream migration and survival to the extent that they contribute to increased water temperatures (Keefer et al. 2008, Crozier et al. 2014). The factors responsible for the losses of adult sockeye salmon migrants are not fully established, but are thought to be related to stream flow and temperature (Arthaud and Morrow 2013). Adult sockeye salmon return to the Salmon River in late summer, when flows often reach low levels and water temperatures peak.

2.4.2.5 Estuary Habitat

The Columbia River estuary provides important migratory habitat for yearling SR sockeye salmon. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent five-year review (NMFS 2016b), have improved access and connectivity to floodplain habitat. From 2007 through 2019, the Action Agencies implemented 64 projects, including dike and levee breaching or lowering, tide gate removal, and tide gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents more than a 2.5 percent net increase in the connectivity of habitats that produce prey used by juvenile sockeye salmon (Johnson et al. 2018). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Floodplain habitat restoration can affect the performance of juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects and corophiid amphipods) (PNNL and NMFS et al. 2018) are also exported to the mainstem and off-channel habitats behind islands and other landforms, where they become available to juvenile salmon and steelhead migrating in these locations. There is very little information available about the prey of sockeye salmon in Pacific coast estuaries. Adult dipterans and chironomid larvae were the primary food items seen in juvenile sockeye salmon captured in Russia's Kamchatka River estuary (Bugaev and Karpenko 1984, as cited in Higgs et al. 1995). Insects were the primary prey of subyearling sockeye salmon in the estuary of the Fraser River (Birtwell et al. 1987), although these were not identified as terrestrial versus wetland-dependent. Based on these observations from different systems, juvenile SR sockeye salmon are likely to feed on chironomid insects, like other Columbia River salmonids. Thus, while most juvenile sockeye salmon may not enter a tidal wetland channel, they derive benefits from wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry.

As discussed in Section 2.4.2.1.2 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, the levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, and they are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life history types.

2.4.2.6 Predation

A variety of avian and fish predators consume juvenile SR sockeye salmon on their migration from tributary rearing areas to the ocean. This section discusses predation rates and describes management measures to reduce the effects of the growth of predator populations within the action area.

2.4.2.6.1 Avian Predation

Avian Predation in the Lower Columbia River Estuary

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and plume is about one third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge to the lower river, especially during spring, contributes to reduced turbidity, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including SR sockeye salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001 to 2015, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island.

We do not have estimates of predation rates for Caspian terns on juvenile SR sockeye salmon for the East Sand Island colony before the management plan was implemented, but these averaged 4 to 5 percent for juvenile SR spring/summer Chinook and UCR spring-run Chinook salmon

(Evans and Payton 2020) (Appendix B), which migrate during the same period. Since then, predation by East Sand Island terns on SR sockeye salmon has averaged 1.8 percent, similar to post-management values for the spring and summer Chinook salmon species. Any improvement in survival for SR sockeye salmon would have been offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on SR sockeye salmon in 2003 to 2014 was 4.2 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[146] where smolts are likely to constitute a larger proportion of the diet. The average annual predation rates on SR sockeye salmon reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (2.4 during 2015 to 2017 and 0.9 percent in 2018) therefore cannot be directly compared to those before management began, and are likely to underestimate predation rates in the estuary.

Avian Predation in the Hydrosystem Reach

The following paragraphs describe avian predation in the mainstem lower Snake and Columbia Rivers from the tailrace of Bonneville Dam to the head of Lower Granite Reservoir.

SR sockeye salmon survival in the mainstem is affected by avian predators that forage at the mainstem dams and reservoirs. The 2008 biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. These efforts have reduced avian predation on juvenile salmon at the dams. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84 to 94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes

[146] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[147]

SR sockeye salmon are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been focused on keeping terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015, and similar efforts by Reclamation are in progress at Goose Island. Predation rates on this ESU, which were 1.5 percent for terns on Crescent Island before implementation of the IAPMP, were reduced to less than 1 percent (predation rates for terns on Goose Island and North Potholes Island remained less than 0.1 percent) (Evans and Payton 2020) (Appendix B). However, the movement of terns to Blalock Islands in John Day Reservoir (Collis et al. 2019) increased predation rates on SR sockeye salmon from 0.2 percent to 1.8 percent (Evans and Payton 2020), indicating little if any change in the likelihood of survival.

Predation by gulls was not considered to warrant management actions at the time the IAPMP was developed, and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this ESU by gulls on Miller Rocks averaged 6.2 percent during 2007 to 2019 (Evans and Payton 2020) (Appendix B). Predation rates on SR sockeye salmon were less than 2 percent per colony for gulls nesting on Island 20, but higher than 2 percent at Badger, Crescent, and Blalock Islands in recent years (Evans and Payton 2020).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on SR sockeye salmon after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts overestimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling

[147] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams" (Zorich et al. 2012).

frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead, and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different although related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood we are able to influence adult returns (an additive effect), but the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, also will be important.[148]

With respect to management of terns in the estuary, we do not have an estimate of average annual predation rates by Caspian terns on SR sockeye salmon before management of the East Sand Island colony (Evans and Payton 2020) and therefore cannot evaluate whether management of this colony has improved the likelihood of survival for these outmigrants. Post-management predation rates have averaged 1.8 percent per year, which are relatively low. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling, have reduced average annual predation rates from 4.2 percent to less than 1 percent (Evans and Payton 2020), a small decrease. However, in this case, predation rates on SR sockeye salmon are likely to have increased because thousands of these birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[149]

2.4.2.6.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin (reviewed in ISAB 2015). Before the start of the Northern Pikeminnow Management Program (NPMP) in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River (including the hydrosystem

[148] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

[149] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

reach) each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). An average of five adult sockeye per year, were incidentally caught in the Sport Reward Fishery, system-wide (i.e., in the lower Columbia River and the hydrosystem reach), during 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were SR sockeye salmon.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). They reported zero sockeye salmon killed and/or handled during the 5-year period. In addition, they caught, but did not remove, an annual average of 967 smallmouth bass and 379 walleye at the two dam angling sites combined over the last 5 years (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). The Oregon and Washington Departments of Fish and Wildlife, which manage these two non-native predator species, are currently discussing the possibility of removing smallmouth bass and walleye from the system when captured by the Dam Angling Program (as with pikeminnow). Both agencies have already removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these species, in addition to pikeminnow, both in the lower Columbia River and the CRS reservoirs (i.e., hydrosystem reach), would incrementally improve juvenile salmonid survival during their migration to the ocean.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile sockeye salmon, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. Williams et al. (2018) found a lower than average abundance (1990 to 2018) for northern pikeminnow in The Dalles and John Day Reservoirs along with a two to three times higher than average abundance for smallmouth bass and walleye in the same reservoirs. With the exception of the John Day forebay area, smallmouth bass abundance index values calculated for 2018 were the highest observed since 1990. Abundance index values provide a means to characterize relative predation impacts (Williams et al. 2018). Similarly, in 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP, as well as a substantial increase in their predatory impact in the lower Snake reservoirs since program design and implementation. Also compared to previous years, walleye were relatively abundant in both The Dalles and John Day Reservoirs during 2018 spring sampling, but few were encountered during the summer sampling. The greatest walleye abundance indices were observed in the John Day Dam tailrace and mid-reservoir, with the tailrace value being the highest recorded abundance to date (Williams et al. 2018). These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal still remains unclear. The complexity of inter-species interactions, combined with inter-reservoir variability and environmental variability, make this a difficult research question to answer without a more intensive sampling and evaluation program (Williams et al. 2018, Winther et al. 2019). However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the sockeye salmon that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of sockeye salmon populations, including SR sockeye salmon. As such, it likely continues to benefit the ESU.

2.4.4.6.3 Pinniped Predation

Marine mammal predators of salmon have increased considerably along the northwest United States coast since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions, Steller sea lions, and harbor seals all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. ODFW counted the number of individual California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, from 1997 to 2017. The data from this study serve as our best evidence that California sea lion abundance within the Columbia River has increased in recent years during the adult SR sockeye salmon migration through the Columbia River Estuary in June (Table 2.4-7). Upstream migrating sockeye salmon are likely encountering outmigrating California sea lions and Steller sea lions as they move toward breeding grounds outside of the Columbia River basin. There are no estimates for the proportion of sockeye salmon that are consumed by pinnipeds in the Columbia River; however, the overall impact of pinniped predation on salmon is likely related to overall pinniped abundance. Rub et al. (2018) found evidence that recent increases in pinniped abundance in the

Columbia River have likely resulted in increased predation rate in recent years. Numbers of pinnipeds counted during June when sockeye salmon are migrating have increased substantially in recent years, from about 45 pinnipeds in 2008 to 2009 to over 500 in 2014 to 2017 (Wright 2018).

Table 2.4-7. Maximum monthly counts of California sea lions at Astoria, Oregon, East Mooring Basin, 2008-2017 (counts ended in June 2017, so more recent data are not available) (Wright 2018). Counts during the peak of the sockeye salmon run in June are shown in bold.

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2008	40	56	67	126	162	**46**	**6**	191	213	204	273	157
2009	27	42	84	118	173	**45**	**38**	346	376	241	89	84
2010	58	93	136	229	216	**157**	**29**	316	356	265	98	54
2011	19	42	77	155	242	**126**	**11**	302	246	85	159	106
2012	20	27	82	240	201	**92**	**19**	212	187	147	91	21
2013	37	149	595	739	722	**153**	**8**	368	377	208	182	100
2014	237	586	1420	1295	793	**90**	**32**	423	492	369	94	126
2015	260	1564	2340	2056	1234	**623**	**37**	394	1318	459	84	208
2016	788	2144	3834	1212	1077	**620**	**3**	291	1004	878	235	246
2017	1498	2345	808	1131	1204	**573**						

Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019, respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the mainstem of the Columbia River between river mile 112 and McNary Dam (river mile 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

Although pinniped presence in the Bonneville tailrace has increased in the last decade (Tidwell et al. 2020), most pinnipeds leave the area before the June peak of the sockeye salmon migration through Bonneville Dam in June and July (Figure 2.4-8). Thus, while consumption of SR sockeye salmon may have increased somewhat, predation of adult SR sockeye in the Bonneville tailrace is rarely observed (Tidwell et al. 2020) and is likely low. A small number (zero to five) of California sea lions have also been observed in Bonneville Reservoir.

Pinniped Predation of Salmonids by Week

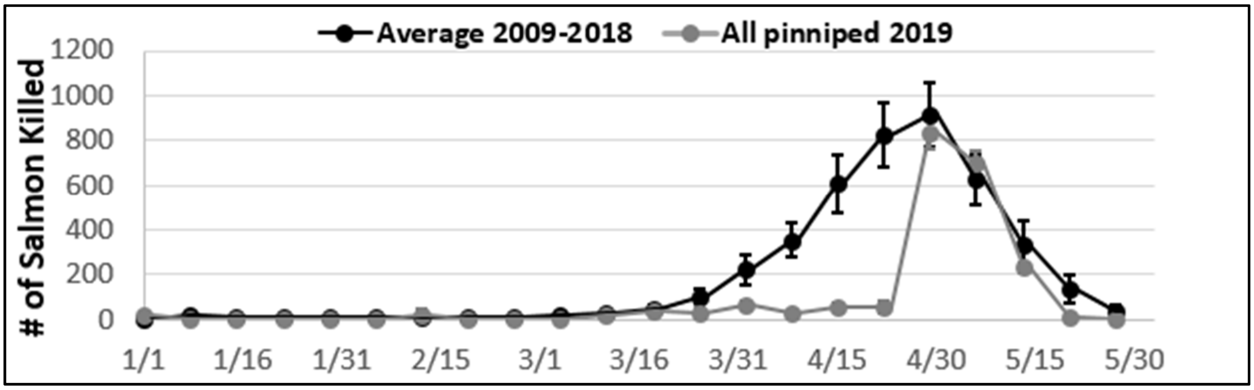

Figure 2.4-8. Temporal distribution of all salmonids that crossed Bonneville Dam and weekly adjusted predation estimates (i.e., # of salmonids killed) of these salmonids by Steller sea lions (SSL) and California sea lions (CSL) during the spring sampling period at Bonneville Dam. The predation data labeled "Average 2009– 2018" is the combined weekly average predation by both pinniped species over the last 10 years. All error bars represent the Standard Error of the estimates (Tidwell et al. 2020).

Concerns about predation rates on salmon and steelhead led the Corps to construct and install sea lion exclusion devices at all the adult ladder entrances of Bonneville Dam in 2006. These devices are designed to block pinnipeds from entering the ladders while allowing fish passage. The sea lion exclusion devices are installed at all eight ladder entrances at Bonneville Dam but may be removed when adult SR sockeye salmon are passing in June when pinnipeds are absent to reduce passage delay. In addition, the Corps has installed smaller physical exclusion gratings on the 16 FOGs along the face of Powerhouse 2 that allow fish to enter the collection channel and pass via the Washington shore ladder. When installed, the sea lion exclusion devices and FOGs successfully prevent pinnipeds from entering the adult fish ladders, and thus further minimize opportunities to prey on SR sockeye salmon.

2.4.2.7 Research, Monitoring, and Evaluation Activities

The primary effects of the past and present CRS-related RME program on SR sockeye salmon are associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods that can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates; and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were SR sockeye salmon. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the SR sockeye salmon ESU by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of SR sockeye salmon that have been handled (or have died) each year using the average annual take reported from 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of SR sockeye salmon associated with the Smolt Monitoring Program and the CSS (which had assumed all fish "taken" by the program were natural-origin fish) were as follows:
  - Zero hatchery and zero natural-origin adults were handled.
  - Zero hatchery and zero natural-origin adults died.
  - Zero hatchery and 1605 natural-origin juveniles handled.
  - Zero hatchery and 28 natural-origin juveniles died.
- Average annual estimates for SR sockeye salmon handling and mortality for all other RME programs were as follows:
  - 20 hatchery and 28 natural-origin adults were handled.
  - Zero hatchery and zero natural-origin adults died.
  - 9,470 hatchery and 1,058 natural-origin juveniles were handled.
  - Six hatchery and two natural-origin juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RME program has, on average, affected 36.4 percent of the natural-origin adult (recent, 5-year average) run (arriving at the mouth of the Columbia River) and 14.0 percent of the naturally-produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (i.e., trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects SR sockeye salmon.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the ESU level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.4.2.8 Critical Habitat

The condition of SR sockeye salmon critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized here in Table 2.4-8. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, inputs of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for SR sockeye salmon production have been weakened. Conditions in the hydrosystem reach were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for SR sockeye salmon have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.4-8. Physical and biological features (PBFs) of designated critical habitat for SR sockeye salmon.

Physical and Biological Feature (PBF)	Components (essential features) of the PBF	Principal Factors Affecting Condition of the PBF
Spawning and juvenile rearing areas	Spawning gravel, water quality, water quantity, water temperature, food, riparian vegetation, access.	Essential features in much of the area surrounding the natal lakes and headwaters remain in functional condition (recreational, wilderness, and similar land use designations that restrict human activities). Legacy effects of increased sediment loads and elevated stream temperatures on substrate and water quality in parts of the Sawtooth Valley and Stanley basin (historical grazing, mining, timber harvest, and wildfire). Potential for elevated suspended sediment and for nutrients and toxic contaminants to reach the spawning lakes, lessened by USFS moving campsites away from shorelines, removing sewage from commercial facilities at Redfish Lake via a contained sanitation system, restoring riparian habitat, etc. (recreational and commercial activities). Passage barrier at the outlet of Stanley Lake and weirs at the Sawtooth Fish Hatchery and Redfish Lake Creek (safety net hatchery operations).
Adult and juvenile migration corridors	Substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions.	*Effects on migration corridor PBFs apply to the single extant population.* Legacy effects of increased sediment loads and elevated stream temperatures on substrate and water quality in parts of the Salmon River migration corridor (historical grazing, mining, timber harvest, and wildfire). Elevated temperatures and degraded riparian conditions in the lower Snake River above Lower Granite Dam and in the mainstem Salmon River portions of the migration corridors (water withdrawals and flow regulation).

Physical and Biological Feature (PBF)	Components (essential features) of the PBF	Principal Factors Affecting Condition of the PBF
		Alteration of the seasonal flow regime in the lower Columbia and Snake Rivers with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph has had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderate negative effect in lower flow years. Alteration of the seasonal mainstem temperature regime in the Columbia and Snake Rivers due to thermal inertia associated with the CRS reservoirs. Generally cooler temperature in the spring and warmer temperatures in late summer and fall (hydrosystem development and operations).[1] This alteration has not negatively affected the migration corridor for juvenile SR sockeye salmon, which emigrate in the spring. However, water quality is negatively affected for adults, which migrate through the hydrosystem during June and July. To prevent migration delays (improve safe passage) in the lower Snake River, the Action Agencies release cold water from Dworshak Dam on the North Fork Clearwater River so that temperatures in the Lower Granite tailrace do not exceed 68°F and operate fishway cooling pumps at Lower Granite and Little Goose Dams. Reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume (hydrosystem development), may have reduced "cover/shelter" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining). The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and uses "environmentally acceptable lubricants" where feasible. Increased exposure of juveniles to TDG in the lower Snake and Columbia Rivers and at least 35 miles below Bonneville Dam during involuntary and flexible spring spill[2] (hydrosystem development and operations) has reduced water quality in the migration corridor for juvenile sockeye salmon. The incidence of adverse effects (GBT in juveniles) appears to have been small (1

Physical and Biological Feature (PBF)	Components (essential features) of the PBF	Principal Factors Affecting Condition of the PBF
		to 2 percent) in recent years. Most adult sockeye salmon migrate through the hydrosystem during summer; therefore only the earliest migrants are exposed to elevated TDG during the spring spill period. The existence and operation of the hydrosystem has reduced the safe passage PBF by creating conditions that delay and injure/kill some juveniles and a smaller proportion of adults in the migration corridor. However, the functioning of the safe passage PBF has increased substantially for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult sockeye salmon during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past the dams or overwintering within the fish facilities or turbine units). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile sockeye salmon because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems). Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Increased opportunities for avian and fish predators in the tailraces of mainstem dams. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, propane cannons, and limited amounts of lethal take. Fish predation is addressed by dam angling at several dams. Delays of adults at the ladder entrances at Bonneville Dam has increased the risk of pinniped predation

Physical and Biological Feature (PBF)	Components (essential features) of the PBF	Principal Factors Affecting Condition of the PBF
		(excessive predation related to hydrosystem development and operation) in the migration corridor. Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitats for rearing and prey production. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling sockeye salmon by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the Caspian Tern management Plan and the Double-crested Cormorant Management Plan on East Sand Island may be reducing excessive predation on juvenile sockeye salmon in the migration corridor, although species-specific data for tern predation are lacking. Implementation of the Double-crested Cormorant Management Plan may have contributed to, or at least coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island. Concerns about expanded fish predator habitat and lack of cover in reservoirs; introduction of non-native piscivorous fish species (excessive predation)

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Spill is characterized as "involuntary" when water is spilled over a dam's spillway because it cannot be stored in a reservoir behind the dam or passed through turbines to generate electricity, such as during maintenance activities, periods of low energy demand, or periods of high river flow. Involuntary spill is most common in the spring.

Habitat quality in tributary streams in the lower Snake River basin within the Interior Columbia Recovery Domain varies from excellent in wilderness and roadless areas (much of the watershed areas surrounding the natal lakes in the Sawtooth Valley) to poor in areas subject to heavy agricultural and urban development (valley bottoms along the mainstem Salmon River). Critical habitat throughout much of the area has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems within the Interior Columbia Recovery Domain (NMFS 2016b). As discussed above, many tributary habitat improvement actions have been implemented throughout the Snake River basin by Federal, tribal, state, local, and private entities. The Action Agencies' tributary habitat program has been protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. These actions are improving the condition of PBFs in specific locations.

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho's Clean Water Act Section 303(d) list for water temperature. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016b). They can negatively impact critical habitat and the organisms associated with these areas.

Habitat quality of migratory corridors in this area was substantially affected by the development and operation of the CRS dams and reservoirs in the mainstem lower Snake and Columbia Rivers, Reclamation tributary projects, and privately owned dams in the Snake and upper Columbia River basins. Hydrosystem development modified natural flow regimes, resulting in warmer late summer/fall water temperatures. Changes in fish communities have led to increased rates of piscivorous predation on juvenile salmon and steelhead. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines and juvenile bypass systems, also have killed some outmigrating fish (NMFS 2016b). However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented measures in the juvenile and adult migration corridor, including 24-hour volitional spill, surface passage routes, upgrades to juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

In addition, basinwide water management activities, including the operation of the CRS water storage projects for flood control, power generation, and water withdrawals, have substantially reduced average monthly flows at Bonneville Dam during May to July and increased them during October to March compared to an unregulated system. Reduced spring flows, combined with the existence of mainstem dams, increased travel times during the juvenile outmigration period for SR sockeye salmon, increasing the risk of predation. Since salmon and steelhead were listed and critical habitat was designated under the ESA, the Action Agencies have made substantial changes to minimize these operational effects by limiting storage reservoir elevations to minimums needed for flood risk management and passing more water during the spring refill period. By taking these actions, the Action Agencies have increased flows in the spring and summer, which helps replicate the natural hydrograph. As a result, the functioning of the migration corridor has been improved by reduced exposure to predators, increased turbidity (which can provide visual cover), and increased access to cover and prey in nearshore mainstem habitat.

The function of juvenile migration habitat for yearling SR sockeye salmon in the lower Columbia River estuary has been reduced by the conversion of more than 70 percent of the original marshes and spruce swamps to industrial, transportation, recreational, agricultural, or urban uses. Water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. Reduced sediment delivery to the lower river and estuary, combined with in-water structures that focus flow in the navigation channel and bank armoring, have altered the development of habitat along the margins of the river. All of these changes have reduced the availability of prey for smolts between Bonneville Dam and ocean entry.

In the hydrosystem reach, altered habitats in project reservoirs and tailraces create more favorable habitat conditions for fish predators; the latter include native northern pikeminnow and non-native walleye and smallmouth bass. The effects of the non-native species and those of pikeminnow, to the extent they are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea lion predation on adult SR sockeye salmon in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary has increased, but is a natural phenomenon and therefore not excessive predation in the context of effects on the functioning of critical habitat.

Restoration activities addressing habitat quality and complexity, migration barriers (e.g., 24-hour and flexible spring spill, new surface passage structures, and improved spillway designs), and water quality have improved the functioning of PBFs in the action area. However, the role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the ESU. More restoration is needed before the PBFs can fully support the conservation of SR sockeye salmon.

2.4.2.9 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including consultation on the operation and maintenance of Reclamation’s upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of SR sockeye salmon, including recent biological opinions issued for SR sockeye salmon and key emergent or ongoing habitat concerns (NMFS 2016b). From January 2015 through May 22, 2020, we completed 384 formal consultations that addressed effects to SR sockeye salmon.[150] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat, improve riparian condition, increase channel complexity, and increase instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data were available), and 118 projects that involved river, stream, floodplain, and wetland restoration. While these projects generally do not target SR sockeye salmon, it is possible that projects in the Sawtooth Valley, Idaho, could have some benefits to habitats used by this species. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., safe passage in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.4.2.10 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of SR sockeye salmon. Recent improvements in passage conditions at mainstem CRS dams, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, tributary habitat improvements, and efforts to improve hatchery

[150] PCTS data query July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

practices and lower harvest rates are positive signs, but other stressors are likely to continue. The recovery plan (NMFS 2015b) identified natural lake habitat, mainstem Salmon River habitat, lower Snake River habitat upstream of Lower Granite reservoir, mainstem CRS migration corridor, estuary habitat, hatcheries, harvest, and predation as limiting factors that continue to negatively affect SR sockeye salmon populations.

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for SR sockeye salmon, as described above. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in the last two decades to improve the functioning of some of these PBFs of critical habitat. For example, surface passage structures and spill operations have improved safe passage for juvenile SR sockeye salmon at mainstem dams. Dworshak Reservoir operations and temperature control structures have improved water quality for adults in the fish ladders in the lower Snake River. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. Similarly, projects that have protected or restored habitat in the Sawtooth Valley or the mainstem Salmon River have improved the functioning of the freshwater spawning and rearing sites and the juvenile migration corridor, respectively. However, the factors described above continue to have negative effects on these PBFs.

2.4.3 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020; Section 2).

2.4.3.1 Effects to Species

2.4.3.1.1 Spill and Seasonal Flow Operations

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams. The intent of flexible spill operations is to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem.[151] Spring spill operations will occur from April 3 to June 20 at the four lower Snake River projects and from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, the four lower Snake River dams and McNary Dam will all operate up to 125 percent TDG spill ("gas cap spill") for a minimum of 16 hours per day, and each project may operate under lower spill levels ("performance standard spill") for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill at all hours. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs maximum spill constraint) for 16 hours per day with 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours; however, once the trigger for adult SR spring/summer Chinook salmon passing Lower Monumental Dam is met,[152] 8 consecutive hours of performance standard spill will be used in the morning at Little Goose Dam to help reduce passage delays of adult SR spring/summer Chinook salmon.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan, unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in performance standard spill periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.4-9.

[151] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

[152] A passage trigger of 25 adult SR spring Chinook passing Lower Monumental Dam was implemented in 2020 per the Flexible Spill Agreement.

Table 2.4-9. Spring spill operations at lower Snake and Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3, 5]	Performance Standard Spill (8 hours per day)[2, 4, 5]
Lower Granite[5]	125% Gas Cap	20 kcfs
Little Goose[6, 7]	125% Gas Cap	30%
Lower Monumental	125% Gas Cap (uniform spill pattern)	30 kcfs (bulk spill pattern[8])
Ice Harbor	125% Gas Cap	30%
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[9]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[10]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility (with the exception of Little Goose and Lower Granite operations described in the notes that follow). Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions, except as noted below.

[5] Lower Granite Exception One - If adult passage delays are observed at Lower Granite Dam, the Corps may implement performance standard spill at Lower Granite Dam for at least 4 hours in the AM (beginning near dawn). Implementation of this modification may also trigger in-season reevaluation of options to balance power principle.

[6] Little Goose Exception One - As soon as practicable (and, in any event, no more than 24 hours) after a cumulative total of 25 adult spring Chinook salmon (not including jacks) pass Lower Monumental Dam, operate Little Goose spill at 30 percent spill for 8 consecutive am hours (April 1 to 15, start at 5 AM; April 16 to June 20, start at 4 AM).

[7] Little Goose Exception Two - During periods of involuntary spill, spill at 30 percent for 8 hours/day during the hours described in footnote 6 above and store additional inflows that exceed hydraulic capacity in the forebay above MOP if necessary. When it is necessary to pond water to achieve the lower spill levels due to high inflow, water stored above MOP should be drafted out over the remaining hours by increasing spill to pass inflow from 1200 to 1600 hours (or 1300 to 1700 hours from April 3 to 15), then increasing spill as necessary from 1600 to 0400 (or 1700 to 0500 hours from April 3 to 15) to draft the pool back to MOP. If it is forecast that the drafting spill will generate TDG levels in the tailrace in excess of 130 percent TDG, use all 16 hours to return the pool to MOP.

[8] If the specified spill level at bulk pattern exceeds the gas cap, then spill pattern will be changed to uniform.

[9] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[10] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 21 to August 31 at the four lower Snake River projects, and June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.4-10. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Snake and Columbia Rivers. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.4-10. Target summer spill levels at lower Snake and lower Columbia River projects.

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
Lower Granite[2,3]	18 kcfs	Removable spillway weir or 7 kcfs
Little Goose[2,3]	30%	Adjustable spillway weir or 7 kcfs
Lower Monumental[2,3]	17 kcfs	Removable spillway weir or 7 kcfs
Ice Harbor[2,3]	30%	Removable spillway weir or 8.5 kcfs
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[4]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] Spill levels may not be achievable on all hours if water is stored or flows are below 20 kcfs, which can occur in the month of August, especially at Lower Granite and Lower Monumental Dams when flows are at or below 30 kcfs (see FOP for additional information).

[3] Summer spill from August 15-August 31 may be through the spillway weir or through conventional spillbays using the appropriate FPP spill pattern for each project. The spillway weirs will be operated consistent with operational criteria in the FPP.

[4] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March, decreased flows from May through August, and little change in flows in April and September) described in the Environmental Baseline will continue to affect the lower Snake and lower Columbia mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in all project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce high TDG events associated with spill in the winter, which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. The proportional effect on flow is higher in the lower Snake River than in the lower Columbia River due to its smaller flow volume. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.4-9).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

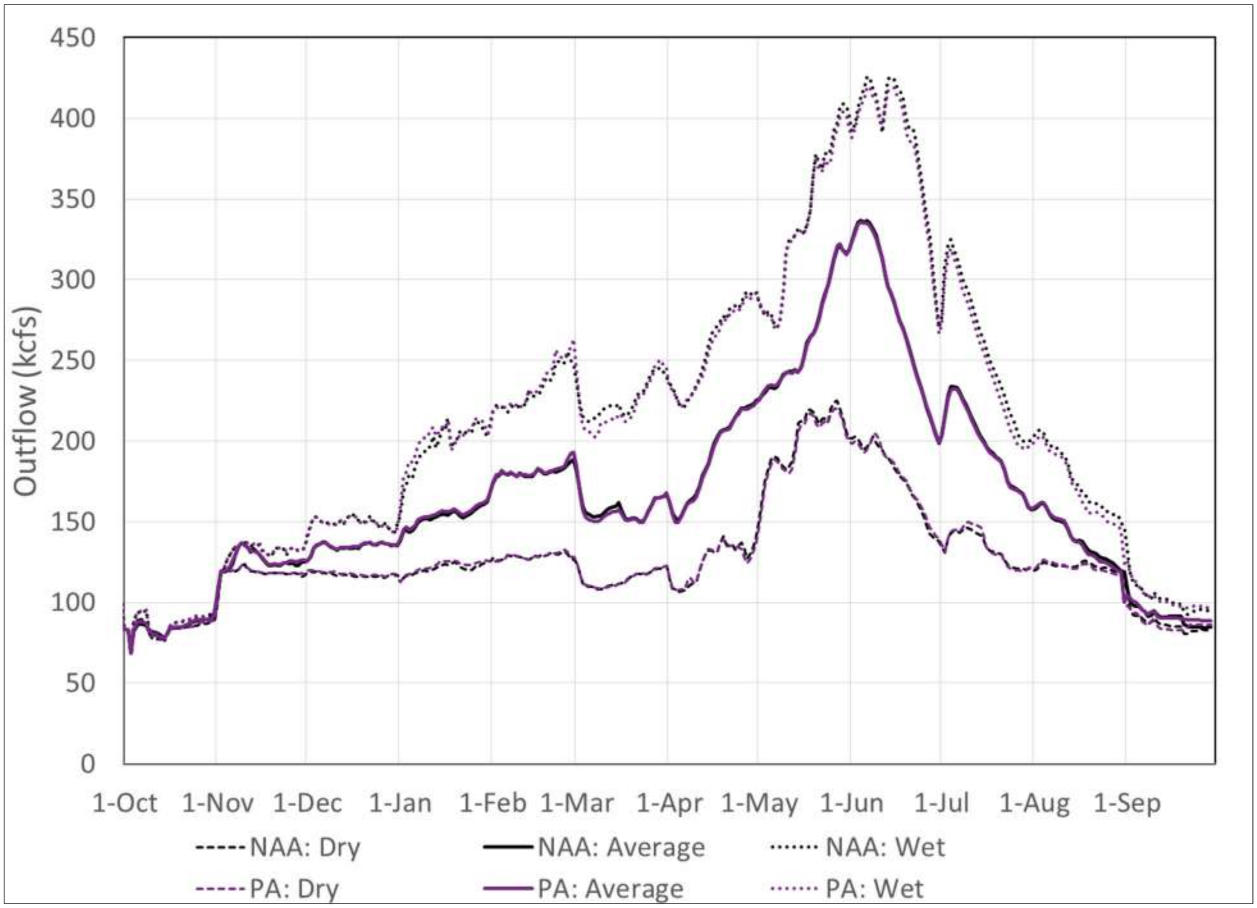

Figure 2.4-9. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

Juvenile SR sockeye salmon migrate through the lower Snake and Columbia Rivers in May to early June, and the Action Agencies will operate to meet seasonal flow objectives to support juvenile migrants during that period. Adult SR sockeye salmon migrate primarily in late June to July. The proposed change in flow would be too small to affect summer river temperature, which would be the attribute of highest concern. The associated effects on SR sockeye smolts or adults should not change from recent conditions by a meaningful amount.

The effects of these hydrosystem operations and the non-operational measures on SR sockeye salmon and its habitat are described below.

2.4.3.1.2 Water Quality

The operation of the CRS will continue to affect water quality parameters in the mainstem migration corridor. This includes delayed spring warming, delayed fall cooling, reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs, and the continued releases of cool water from storage at Dworshak Dam to moderate lower Snake River water temperatures from June through September.

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacity spill. These events will continue to occur most frequently in May and June but may also occur in other months.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spring spill operation would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. Smolts typically migrate at depths that effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020). Data from all fish sampled in the CRS Gas Bubble Trauma Monitoring Program (1996 to 2019) indicate that signs of GBT were almost non-existent below 120 percent TDG, increased slightly between 121 percent and 125 percent TDG, and then increased in incidence and severity when TDG levels exceeded 125 percent (FPC 2019). The available information in Zabel (2019) and Widener et al. (2020) suggests that the relatively high TDG exposure often exceeding 125 percent during high flow years (e.g., 2006 and 2011) did not reduce smolt survival through the CRS. In 2019, when spill volume, spill as a percentage of flow, and TDG were higher than the recent long-term averages, the estimated survival rate for juvenile SR sockeye salmon from Lower Granite to Bonneville Dam was 43.4 percent. This is over 10 percent lower than the recent average of nearly 56 percent (2009 to 2019, excluding 2015 to 2017—see earlier discussion). Given the annual variability in juvenile survival data, and the numerous factors that can affect juvenile survival rates (e.g., tailrace conditions, predators, fish condition, etc.), no definite conclusions can be drawn from this single year of data with respect to the longer term effects of higher TDG levels resulting from the flexible spring spill operation on juvenile survival. However, the proposed flexible spring spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (likely not measurable based on reach survival studies) increase in mortality of juvenile SR sockeye salmon.

Adult SR sockeye salmon typically migrate between Bonneville and Lower Granite Dam starting in June, so only the earliest migrants would be affected by the proposed flexible spring spill operation. Adults migrate at depths which reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spring spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality for adults that are exposed (i.e., that migrate upstream of Bonneville Dam prior to the start of the summer spill season).

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[153] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (EPA 2018, Perhar and Arhonditsis 2014). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for

[153] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

juvenile and adult migrants. Any effects of oil and grease on SR sockeye salmon are likely to be very small and are not expected to detectably affect reach survival estimates.

Sediment Transport

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency especially during the spring freshet. The increased water transparency hypothetically increases the exposure of SR sockeye salmon juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile SR sockeye salmon spend only a few days in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

2.4.3.1.3 Project Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems (BPA et al. 2020). Maintenance activities evaluated and covered under this opinion can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance, as summarized in Section 1.3 of this opinion and in further detail in BPA et al. (2020).

Fishway structures (e.g., fish ladders, screens, bypass systems) will be routinely maintained and temporarily removed from service on a scheduled basis during the established in-water work period (December to March), in accordance with the Fish Passage Plan and coordinated through FPOM to minimize impacts to adult and juvenile migrants. At Bonneville Dam, routine dredging in the forebay and rock removal in the spillway will occur every year or two to ensure reliable operation and structural integrity of the fishways. Turbine unit maintenance is planned at all dams and will be coordinated through FPOM to minimize and avoid delay, injury, and mortality.

Routine outages of fishways are necessary to maintain reliability, but these temporary outages can cause delay and mortality for adult and juvenile migrants that attempt to migrate at the time of the outage. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be relatively low numbers Snake River sockeye salmon that are migrating, and these effects will occur at extremely low levels similar to what was observed in the recent past. Passage delay and conversion rates will be monitored and maintenance schedules may be modified through FPOM or adaptive management if evidence indicates elevated delay and mortality are occurring.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization and major rehabilitations. Non-routine maintenance expected in the timeframe of the proposed action includes the installation of improved fish passage (IFP) turbines at three out of six turbine units at Ice Harbor Dam. At McNary Dam, turbine replacement is expected to begin within the next 15 years. At John Day Dam, turbine replacement may begin, but it is uncertain at this time if it will be completed, within the 15-year period of the proposed action. The proposed maintenance at Grand Coulee could result in outages and additional spill in limited situations, but changes to total outflows are not expected. The Corps will repair the existing jetty and retaining wall located near the north shore adult ladder entrance at Little Goose Dam, where significant erosion has occurred. Replacing the jetty with large rock and/or large coffer cells will restore passage conditions to pre-2011 levels at the north shore ladder entrance when spill exceeds 30 percent at Little Goose Dam. Non-routine maintenance (related to turbines or spillbays) expected in the proposed action can increase TDG during uncontrolled spill by temporarily reducing powerhouse capacity and may cause suboptimal tailrace conditions which can delay passage. The installation of IFP turbines will likely improve turbine survival and reliability once completed. Repairing the jetty at Little Goose Dam will likely reduce delay for adults and improve passage conditions when spill exceeds 30 percent. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce risk to adults and juveniles.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated with NMFS and through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize negative effects on fish. Fish passage metrics will be monitored with counts and PIT tags to ensure unscheduled maintenance activities do not result in negative impacts to the ESU.

Overall, scheduled maintenance activities are expected to continue to negatively affect very small numbers of adult Snake River sockeye salmon annually. A few adults will be delayed or die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. Very few adults and juveniles will likely be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult Snake River sockeye salmon will likely continue to result in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes will continue to minimize the impacts.

2.4.3.1.4 Adult Migration/Survival

Excluding the year 2015, recent adult survival rate estimates for SR sockeye salmon have averaged about 77 percent from Bonneville to McNary Dam (2010 to 2019), about 89 percent from McNary to Lower Granite Dams (2010 to 2017), and about 65 percent from Bonneville to Lower Granite Dams (2010 to 2017). This excludes the extremely poor survival year of 2015, when only 15 percent of adult SR sockeye salmon survived from Bonneville to McNary Dam and only 4 percent survived from Bonneville to Lower Granite Dam due to abnormally high water temperatures (NMFS 2016b). Lower Granite and Little Goose Dams have been equipped with cool-water “showers” to reduce temperature differentials within the adult fish ladders and in the forebay at the ladder exits to reduce delays and potentially improve adult survival rates. Opportunities for this type of improvement are being evaluated at the remaining six mainstem dams, but if the temperatures experienced in June and July of 2015 were to recur, they would likely result in similarly low survival rates, especially in the Bonneville to McNary Dam reach, where the great majority of sockeye salmon perished. Additional measures to identify and reduce ladder temperature differentials at CRS dams will be investigated and implemented if necessary and feasible.

A review and analysis by Crozier et al. (2014) found that the most significant factors associated with adult SR sockeye salmon fallback and upstream survival were a history of juvenile transport, warmer temperatures, and lower flows during upstream migration. Spill volume was not significantly associated with fallback for this species. This is important because increased fallback is related to lower conversion rates to natal tributaries for adult salmonids (Crozier et al. 2014, Keefer et al. 2005). On average (2008 to 2019) only 5 percent of adult SR sockeye salmon had passed Bonneville Dam by June 21. Thus very few adults would be exposed to effects of the flexible spring spill operation. Thus, the flexible spring spill operation would not be expected to substantially alter fallback rates or the survival of adult SR sockeye salmon migrating in the lower Snake or Columbia Rivers prior to June 21 or June 15, respectively.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. This change would affect very small numbers of adult SR sockeye salmon that were still migrating after August 15 by improving adult ladder attraction conditions. Few adult SR sockeye salmon migrate in August; on average (2010 to2019), 95 percent of the run had passed Lower Granite Dam by July 31 (DART 2020g). Thus, we expect that this change in operation will not affect large numbers of SR sockeye salmon. However, the installation of devices to provide cool water in the fish ladders and forebay exit areas (ladder cooling structures) at Little Goose and Lower Granite Dams will continue to reduce fallback by preventing rejection of the ladders and forebay exit areas.

On average (2008 to 2019) only 5 percent of adult SR sockeye salmon had passed Bonneville Dam by June 21. Thus very few adults would be exposed to effects of the flexible spring spill operation.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14, unless adjusted due to (rare) low flow occurrences in the Snake River to meet authorized project purposes. Maintaining the increased operating range by 6 inches at the lower Snake River dams (MOP 1.5-foot range) as implemented in 2019 and 2020 has not yet been fully evaluated under a range of flow years. The increase in operation range is expected to slightly reduce the average flow rate in the reservoirs, but the flow change is minimal and is not expected to affect adult migration timing or survival rates.

The Action Agencies propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP (262.5 to 264.5 feet), except during the spring spill period, when the John Day forebay operating elevation window will be increased. From April 10 to June 1–15, John Day Reservoir elevation will be held between 264.5 feet and 266.5 feet to deter piscivorous Caspian terns from nesting in the Blalock Islands Complex (see Section 2.4.3.1.9). Following this operation, John Day Reservoir elevation would return to MIP + 2 feet operation through August 31. The increase in operating range is expected to slightly reduce velocities in John Day Reservoir, but the velocity change is not expected to affect adult migration timing or survival rates.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. PIT-tag data indicate that adult SR sockeye salmon have migrated through the Snake River prior to this operation beginning, so we expect there will be no effect on adult migration timing or survival for this ESU.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for adult salmonids passing through the turbine units in June, but the number of adults affected should be extremely low because of the short time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure and improve ladder attraction conditions for adult SR sockeye salmon, but would also slightly reduce turbine unit survival for adult salmonids passing through the turbine units. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project (lower Columbia River dams) from April through June. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. Overall adult survival rates of SR sockeye salmon between Bonneville Dam and Lower Granite Dam should not be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range, and only those adults migrating at the earlier part of the SR sockeye salmon run, (June) could be impacted by this change in operations.

Altogether, recent (2008 to 2019) adult survival rates would be expected to continue at similar levels under the proposed action because the minor improvements and impairments discussed above should, on the whole, result in no substantial differences that would measurably affect survival rates. However, these survival rates will be much lower if the mainstem environmental conditions (low flows and high temperatures) of 2015 recur. The installation of ladder cooling structures at Lower Granite and Little Goose Dams has reduced temperature differentials in the adult ladders and forebay exit areas at these projects (improving passage and potentially reach survival), but the great majority of impacts in 2015 occurred downstream of McNary Dam. It is not clear to what extent cooling systems, had they been installed at the lower Columbia River dams, could have improved migration conditions and adult survival. Conditions at the other six mainstem Columbia and lower Snake River dams have been evaluated (Lundell 2019), and this information is being used to determine if ladder cooling structures would be effective at these projects as well. If the information demonstrates that ladder cooling structures are necessary and implementable, the Action Agencies have proposed to design and install them at necessary locations, which would improve the migration success and survival of adult SR sockeye salmon.

2.4.3.1.5 Juvenile Migration/Survival

The Action Agencies propose to continue to provide fish passage spill (conventional and surface passage), operate juvenile bypass systems, and implement other operations (e.g., ice and trash sluiceways, Bonneville corner collector, etc.) for juvenile passage at the eight lower Snake and lower Columbia River dams. Surface passage structures and juvenile bypass systems exist at all four of the lower Snake River dams, and surface passage structures exist at each of the four lower Columbia dams, and three of them have juvenile bypass systems. The Dalles Dam does not have a juvenile bypass system because of low powerhouse passage rates. Increased spill levels resulting from the flexible spring spill operations are expected to have little negative effect on tailrace conditions at Bonneville, The Dalles, McNary, and Ice Harbor Dams, but could cause eddies to form at other dams under low to moderate flow conditions. The latter would likely increase the exposure to predators of juvenile SR sockeye salmon passing through the spillway, thereby reducing spillway survival by a small, but unknown, amount. Increased spill levels at the other dams (excepting The Dalles Dam which will continue spilling at 40 percent) would generally be expected to slightly increase direct dam passage survival rates of inriver migrating smolts as spillway survival rates generally exceed those in the juvenile bypass systems or through the turbine unites. Overall, the survival of inriver migrating juvenile SR sockeye salmon should increase slightly as a result of implementing the flexible spring spill levels at each of the eight mainstem dams. Increases in downstream migration survival are expected to increase population productivity by delivering more smolts to the ocean, resulting in more adults returning.

The proposed operations at Libby Dam, Hungry Horse Dam, Grand Coulee Dam, and Dworshak Dam will alter flows by less than 2 percent during the spring migration period. This would be expected to result in very small increases in travel times in April and May, and small decreases in travel times in June, but should not measurably affect juvenile survival. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

Juvenile SR sockeye salmon survival rates from Lower Granite to McNary Dam in the last 10 years (2010 to 2019) have averaged 61.2 percent (ranging from about 23 percent in 2016 to 94 percent in 2018). Juvenile survival rates from Lower Granite to Bonneville Dams in the last 10 years (2010 to 2019) averaged 44.6 percent (ranging from about 12 percent in 2016 to 71 percent in 2014).[154] Juvenile survival rates from Lower Granite to Bonneville Dam during gas cap spill and flexible spring spill in 2018 and 2019 were 64.3 and 43.4 percent, respectively. Assuming COMPASS model predictions for SR yearling Chinook salmon and steelhead are applicable to juvenile sockeye salmon,[155] travel times from Lower Granite to Bonneville Dam (flexible spring spill up to 125 percent TDG) will be faster and direct survival rates will be slightly higher than during past operations. On average, more juvenile sockeye will pass through spillways and other surface passage routes. However, impaired tailrace egress conditions during higher spill levels could cause juvenile inriver survival rates to be somewhat lower than predicted.

Nearly all SR sockeye salmon smolts migrate in May. The 2019 CSS report hypothesizes that increased spill could substantially reduce latent mortality for juvenile yearling Chinook salmon and steelhead moving downstream through the mainstem dams. If this is correct and latent mortality is similarly reduced for SR sockeye salmon, SARs would also improve; otherwise, survival improvement would be limited to small increases in direct survival.

Juvenile sockeye salmon would likely be exposed to slightly higher TDG levels under the flexible spring spill operation (up to 125 percent TDG) compared to recent operations. If juvenile sockeye salmon do not effectively depth compensate, prolonged exposure to 125 percent TDG could increase GBT symptoms, increase predation susceptibility, and reduce survival. However, in high flow years such as 2011, when TDG was often above 125 percent, survival from McNary Dam to Bonneville Dam for sockeye juveniles was within the typical range, indicating that depth compensation was likely occurring. If monitoring indicates that survival of juveniles is declining due to high spill or high TDG, operations may be modified and evaluated using the Adaptive Implementation Framework.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. Because juvenile SR sockeye salmon have migrated through the hydrosystem by August 1st, they will not be affected by a reduction in summer spill in late August.

The Action Agencies propose to increase the forebay operating range at John Day Dam and will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range. Maintaining the increased operating range by 6 inches at the lower Snake River dams as implemented in 2019 and 2020 has not yet been fully evaluated under a range of flow years; however, mean travel time from Lower Granite Dam to Bonneville Dam improved and was below average for other juvenile spring migrants in 2019 (Zabel 2019, Widener et al. 2020). However, 2019 was a higher flow year, and the increase in operation range by itself is expected to slightly reduce the average flow rate in the reservoirs and slightly increase

[154] We excluded data for 2011 because there were too few PIT-tag detections to make a reasonable estimate of survival to Bonneville Dam. The low 2015 to 2017 survival estimates were strongly affected by the issues at the new Springfield Hatchery that negatively affected smolt condition in those years (see environmental baseline discussion). These low survival rates do not represent typical data quality or passage conditions through the lower Snake and Columbia Rivers and are not expected to recur.

[155] Due to data limitations, COMPASS cannot be used to model juvenile SR sockeye salmon survival.

travel time for juvenile SR sockeye salmon compared to the average of years prior to 2018. While increasing reservoir operating ranges may slightly increase travel times for SR sockeye salmon, we expect that the overall effect of increased reservoir operating ranges and the flexible spring spill operation will reduce travel time through the CRS.[156] We expect recent juvenile survival rates to continue at similar levels under the proposed action.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. These operations will result in no flow past the projects in the Snake River during these periods. Few to no SR sockeye salmon juveniles are expected to migrate through the lower Snake River during this period, so this operation will have extremely minimal to no effect.

As described above (see Section 2.4.3.1.4), under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, but the number of juveniles affected should be extremely low because of the short time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure, would slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, and would slightly increase powerhouse passage rates of juvenile SR sockeye salmon. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

[156] COMPASS estimated an average decrease of 0.4 days for steelhead and 0.9 days in travel time for yearling Chinook salmon from Lower Granite to Bonneville Dam. We expect sockeye salmon travel times to be similarly affected.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams from April through June. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of SR sockeye salmon between Bonneville Dam and Lower Granite Dam, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

Transportation

SR sockeye salmon smolts will continue to be collected for transport at the three Snake River collector projects. The increased spill will result in more juvenile fish going over the spillway and fewer fish being transported on a given date. This effect will be especially pronounced in low to medium flow years. Should TIR ratios continue to demonstrate an overall benefit of transport to SR sockeye salmon, the expected decrease in transport rates resulting from increased spill at the three collector projects would, on average, result in a slight reduction in adult returns.

This decrease in the daily proportion of fish collected due to higher spill would not be offset by effects from starting the transportation program earlier in the spring, as would occur for earlier-migrating SR spring/summer Chinook salmon and SRB steelhead. From 2010 to 2019, less than 5 percent of sockeye salmon juveniles, on average, had arrived at Lower Granite Dam by April 29. Most sockeye juveniles reach the collector projects in the Lower Snake River in May to early June. Thus the proportion of sockeye salmon smolts transported annually is not expected to change substantially if transport is started earlier, and there will be no measurable effect on sockeye salmon SARs resulting from an earlier start to transportation.

The proposed cessation of transport from June 21 to August 15 will reduce the collection and transportation of the latest-migrating SR sockeye smolts. From 2010 to 2019, on average, 95 percent of SR sockeye salmon had arrived at Lower Granite Dam by May 28, but a few smolts continue to migrate in the Lower Snake River after May. These late-migrating smolts generally benefit from transport. However their numbers are so few that the effects of stopping transport from June 21 to August 15 are likely to be unmeasurably small for SR sockeye salmon. The decision of when and whether to stop juvenile fish transport on June 21 would remain subject to the TMT and FPOM decision processes and this action could be changed if smolt outmigration timing shifts later in a given year and ceasing transport on June 21 is determined to be detrimental.

2.4.3.1.6 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to SR sockeye salmon as they migrate through the estuary.

NMFS agrees with ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty about predicting the availability of habitat restoration actions into the future and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management of the restoration program. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the action effectiveness monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program will elucidate how these floodplain reconnections are enhancing conditions for yearling salmonids such as SR sockeye salmon as they migrate through the mainstem, and provide sufficient information to the Action Agencies to help refine site selection and project design through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change considerations and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the influx of insect and amphipod prey to the mainstem migration corridor for juvenile SR sockeye salmon. It is also reasonably certain that these benefits will increase as habitat quality matures, contributing to increased abundance, productivity, and life-history diversity[157]

[157] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile sockeye salmon opportunities to move into wetland habitats for food and refuge from predators. Moreover, the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of the SR sockeye salmon ESU.

of the SR sockeye salmon population. However, other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.4.3.1.7 Tributary Habitat

While the Action Agencies have not proposed to implement tributary habitat projects that will specifically target SR sockeye salmon as part of the proposed action, projects in the Sawtooth Valley that increase flows, or improve riparian area or floodplain functions, could improve juvenile migration or adult-holding conditions for SR sockeye salmon in the Salmon River or its tributaries. However, the effects of these potential improvements for SR sockeye salmon, though likely positive, are too speculative to assess.

2.4.3.1.8 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail in the site-specific biological opinions referenced therein (see Section 2.4.2.2). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

The Snake River Sockeye Salmon Captive Broodstock Program, funded by BPA as mitigation for the CRS, is particularly important for SR sockeye salmon. In fact, the program is largely considered to have averted the extirpation and further loss of genetic diversity of the ESU (NMFS 2015c). As noted in the Environmental Baseline section (see Section 2.4.2.2), in 1991, at the time of the ESA listing of SR sockeye salmon, a partnership of state, tribal, and Federal fish managers initiated the captive broodstock hatchery program to save the Redfish Lake sockeye salmon population. Between 1991 and 1998, all 16 of the natural-origin adult sockeye salmon that returned to the weir at Redfish Lake were incorporated into the captive broodstock program, as well as outmigrating smolts captured between 1991 and 1993, and residual sockeye salmon captured between 1992 and 1995. The program has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and has produced several million eggs and juveniles, as well as several thousand adults, for release into the wild.

The program design includes three phases. The phase 1 priority was genetic conservation and building sufficient returns to support sustained outplanting. While these goals remain an important component of the program, it is also beginning to transition to phase 2, the goal of which is to secure the primary population in Redfish Lake and increase the number of fish available for reintroduction into the ESU’s former range. This transition to phase 2 is possible now that the Springfield hatchery facility is in full production and water chemistry issues have been resolved, and we expect the program to continue contributing to adult abundance. In the future, when program triggers for adult returns are reached, the goal for the program is to move to phase 3, local adaptation. During this phase the program would transition to an integrated broodstock management program that follows a sliding scale to meet escapement and broodstock objectives (NMFS 2015c).

2.4.3.1.9 Predation Management

Avian Predators

Avian Predators in the Lower Columbia River Estuary

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from the USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions are likely to continue current levels of predation at these colonies. In the case of the Caspian terns, we do not have an estimate of predation rates before management of the colony on East Sand Island, but post-management rates have averaged 1.8 percent per year. Although there appears to have been a small decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 4.2 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, cormorant predation in the estuary may be an increasingly important source of mortality for SR sockeye salmon.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

Avian Predators in the Hydrosystem Reach

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia River and Snake River dams. At each dam, bird numbers will continue to be monitored, birds foraging in dam tailraces will be hazed (including, in some circumstances, lethal reinforcement), and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas, and juvenile bypass outfall areas, will also continue. If proven biologically and cost effective, the Corps will deploy laser systems to haze birds foraging near bypass outfalls. Upgrades to existing systems, including bird wires at McNary Dam, will be coordinated through the FPOM and included in the annual Fish Passage Plans. We expect that these measures will continue to reduce levels of predation on juvenile SR sockeye salmon, although Zorich et al. (2012) were unable to quantify the amount of protection.

The Action Agencies propose to continue to address Caspian tern predation at lands that they manage on the interior Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. These measures are likely to preclude use of Crescent Island by Caspian terns. Reclamation will continue passive and active dissuasion efforts for Caspian terns on Goose Island. They have coordinated the timing and duration of the proposed work with USFWS to ensure it will be effective in maintaining the management objectives of fewer than 40 breeding pairs at this site, consistent with the IAPMP. This ongoing suite of colony management actions is likely to continue current levels of predation by terns in the interior Columbia River basin, which is a small improvement compared to the pre-colony management period.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the hydrosystem reach are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

John Day Reservoir—Spring Operations to Reduce Predation Rates by Caspian Terns

The Action Agencies propose to hold the elevation of John Day Reservoir at 264.5 to 266.5 feet from April 10 to June 1 or no later than June 15 each year, or as feasible based on river flows, to inundate bare sand habitat and deter Caspian terns from nesting in the Blalock Islands Complex. Because foraging effort and predation rates increase once chicks hatch, the Action Agencies will begin to increase the reservoir elevation before Caspian terns initiate nesting (i.e., operations may begin earlier than April 10). The timing of the operation will factor in bird observations along with the run timing of juvenile steelhead to determine the dates each year. The Action Agencies will consider bird observations along with the run timing of juvenile steelhead to determine the dates each year. At the conclusion of this operation, the draft to operating range (262.5 to 264.5 feet) will be completed within 4 days. In general, 95 percent of the juvenile sockeye salmon migration passes McNary Dam by June 1 (DART 2020m).

The timing of this operation is based on the expectation that Caspian terns will begin colonizing exposed habitat and start courtship and nest building within days to weeks of returning the reservoir to the 262.5- to 264.5-foot range. In general, chicks hatch about 27 days after eggs are laid, at which point energetic demands and fish consumption rates increase substantially. Thus, we expect that inundating bare sand habitat until after 95 percent of juvenile steelhead pass John Day Dam will also reduce the risk of predation on individuals from the SR sockeye salmon ESU.

Fish Predators

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. This fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the average number of sockeye salmon, including some SR sockeye salmon that will be handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy) will be no more than 1 adult and 10 juveniles per year. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams and will conduct test fisheries at additional dam projects on the Snake River as described in the proposed action (BPA et al. 2020). As the Dam Angling Program evolves and potentially expands, it may help to further reduce predation on juvenile SR sockeye salmon. We estimate that no more than one adult and 10 juvenile sockeye salmon, including some from the SR sockeye salmon ESU, will be caught in the Dam Angling Program per year.

These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of sockeye salmon populations, including SR sockeye salmon.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea lion exclusion devices at all adult fish ladder entrances at Bonneville Dam each year. The installation of sea lion exclusion devices is optional and coordinated through FPOM during the SR sockeye passage season since few pinnipeds are present at that time. The Corps and BPA will implement dam based hazing near ladder entrances when pinnipeds are present in the spring and fall, and will continue to support authorized removal efforts by the states and tribes to keep sea lions away from the area downstream of Bonneville Dam. Hazing and dissuasion shall be supportive of pinniped removal efforts and cover the periods from March 31 through May 31 and August 15 through October 31. The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management Coordination Team and the Sea Lion Task Force, to address changing circumstances as they relate to sea lion harassment efforts and predation monitoring at Bonneville Dam. These ongoing measures are expected to maintain the current very low levels of sea lion predation on SR sockeye salmon in the Bonneville Dam tailrace. If pinnipeds are observed at The Dalles Dam, the Corps may respond with hazing at adult fish ladder entrances.

2.4.3.1.10 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult SR sockeye salmon are likely to be present in shallow shoreline areas, an unknown portion of the ESU will continue to be stunned, harmed or possibly even killed. At present, to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed, and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this ESU that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The present 5-year average number of observed salmonids being stunned and harmed annually by the project is 90,000 juvenile and 1,600 adult salmonids. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[158]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately.

We estimate that, on average, the following number of SR sockeye salmon will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS:
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - 8,460 hatchery and 1,855 natural-origin juveniles will be handled.

[158] Ongoing and future discussions are expected to lead to reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

- 170 hatchery and 30 natural-origin juveniles will die.

- Activities associated with all other RME programs:
  - 139 hatchery and 12 natural-origin adults will be handled.
  - Two hatchery and one natural-origin adult(s) will die.
  - 11,540 hatchery and 1,145 natural-origin juveniles handled.
  - 130 hatchery and five natural-origin juveniles will die.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RME program is expected to affect, on average, up to 19.5 percent of the natural-origin adult (recent, 5-year average) run (arriving at the mouth of the Columbia River) and up to 15.7 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). Given these limits, the effects of RME projects on overall adult and juvenile survival (estimated mortality) may amount to 4 percent (or less) of estimated ESU abundance; however, if reported SR sockeye mortalities continue as they have in recent years, the actual percentage will be lower. The effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the effects of the RME programs on abundance are acceptable and warranted.

2.4.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small improvement to safe passage for inriver juvenile migrants at the eight mainstem dams. Implementation will also affect the volume and timing of flow in the Columbia River, which alters habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.4-11.

Table 2.4-11. Effects of the proposed action on the physical and biological features (PBFs) of designated critical habitat within the action area for SR sockeye salmon.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Spawning and juvenile rearing areas	The proposed action will not change the functioning of spawning and juvenile rearing sites in Sawtooth Valley lakes.
Adult and juvenile migration corridors	*Effects on migration corridor PBFs apply to the single extant population of SR sockeye salmon:* Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. The proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not affect the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal mainstem temperature regime in the Snake and Columbia Rivers due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring, when juvenile SR sockeye salmon are migrating, and warmer temperatures in the late summer and fall. The latter will continue to adversely affect water quality in the adult migration corridor. To prevent migration delays in the lower Snake River, the Action Agencies will continue to release cold water from Dworshak Dam and to operate the fishway cooling pumps at Little Goose and Lower Granite Dams (improved water quality and safe passage). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume, which may reduce “cover/shelter” in the migration corridor. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill at the CRS run-of-river projects in the lower Snake and Columbia Rivers. The effect on water quality in terms of an increase in the incidence of GBT is likely to be very small. The Corps will continue to protect water quality by using best management practices to minimize accidental releases of oil and grease at their projects and to minimize any adverse effects from equipment in contact with the water. The flexible spring operation to 125 percent TDG will lead to degraded hydraulic conditions in the tailrace at Lower Granite, Little Goose, Lower Monumental, and John Day Dams, and may contribute to passage delays for small numbers of adult SR sockeye salmon that enter the lower Columbia River during the spring spill period (reduction in safe passage). The flexible spring operation to 125 percent TDG will increase safe passage in the juvenile migration corridor by a small amount by increasing the likelihood of spillway passage. However, the increased spill levels that are likely to degrade tailrace conditions at Lower Granite, Little Goose, Lower Monumental, and John Day Dams (safe passage in the migration corridor) are also likely to increase the risk of bird and fish predation. Reduced summer spill at the eight mainstem dams during late August will create a small improvement in safe passage by improving adult ladder attraction conditions. However, only small numbers of sockeye are still migrating during that period. Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (increase in safe passage). However, by increasing powerhouse flows, it will decrease safe passage for juveniles and adults by a small amount because some will pass downstream or fall back through a turbine unit. Increasing the operating range for John Day Reservoir will reduce the risk of avian predation while increasing juvenile travel times by a small amount (small reduction in predation and slight decrease in safe passage).

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	The potential cessation of power generation at Snake River projects between 2300 and 0500 hours, October 15 to February 28, is not likely to affect safe passage for SR sockeye salmon because no adults and very few juveniles are present at this time. Continued small increases in obstructions for adult sockeye salmon during routine outages of fishways or turbine units. Very small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities (e.g., to upgrade turbines at Ice Harbor, McNary, and John Day Dams and for a major repair such as the jetty and retaining wall at Little Goose Dam). Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Long-term effect of turbine upgrades will be reduced obstructions (improved turbine survival). Repairing the jetty at Little Goose Dam will also reduce obstructions for adults at that project. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Continued implementation of the Action Agencies' bird, fish, and pinniped predator management programs will continue recent levels of predation risk in the juvenile and adult migration corridors.
Estuarine areas	*Effects on the estuarine areas PBF apply to the single extant population of SR sockeye salmon:* Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels. This will increase access to prey, even for yearling sockeye salmon that migrate in the mainstem channel without entering floodplain sites. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.4.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.2.1), Environmental Baseline (Section 2.2.2), and Effects of the Action (Section 2.2.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including SR sockeye salmon.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.4.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4.3) to the environmental baseline (Section 2.4.2) and the cumulative effects (Section 2.4.4), taking into account the status of the species and critical habitat (Section 2.4.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.4.5.1 Species

The SR sockeye salmon ESU comprises one extant population (Redfish Lake), and two to four extirpated historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) in a single MPG. The Redfish Lake population (since 1993), and reintroduction efforts into Pettit Lake (since 1995) and Alturas Lake (since 1997), have been supported by the Redfish Lake captive broodstock program. Hatchery production has shifted to the BPA-funded Springfield sockeye salmon hatchery program, which first released juvenile sockeye in 2015.

The most recent status review (NMFS 2016b) noted that: 1) adult returns had generally increased through 2014, reflecting improved downstream juvenile and ocean survival, as well as increased juvenile production, 2) juvenile survival rates to Lower Granite Dam had been highly variable, with most of the mortality likely occurring upstream of the confluence with the North Fork Salmon River, and 3) high temperatures in 2013 and 2015 resulted in unusually high mortality rates in both the lower Columbia (Bonneville to McNary Dam) and lower Snake River (McNary to Lower Granite Dam) reaches, as well as in the reach from Lower Granite Dam to the Sawtooth Basin. The most recent status review found that even though there had been substantial progress on the first phase of the recovery approach (using a hatchery-based program to amplify and conserve the stock and to facilitate reintroductions), the overall status of SR sockeye salmon remained at high risk, and no change in its ESA status (Endangered) was warranted.

Recent (2009 to 2013 and 2014 to 2018) 5-year rolling geometric means of spawning abundance have averaged over 900 adults (including both natural-origin and hatchery produced fish), though the most recent (2014 to 2018) returns have been lower that would be expected due to juvenile losses associated with releases from the new Springfield sockeye salmon hatchery program and high adult mortalities in 2015 associated with unusually high June temperatures. The operational issues at the hatchery appear to have been largely resolved beginning with the 2018 outmigration. The recent geometric mean was also affected by a marine heatwave and its lingering effects, which likely contributed to substantially lower ocean survival rates of juvenile sockeye salmon. Some of the negative ocean factors had subsided by spring 2018 and expectations for marine survival were mixed for 2019 outmigrants. SR sockeye salmon may be either more, or less, resilient to changes in the nearshore ecosystem than yearling Chinook salmon in a given year because they forage on plankton rather than juvenile fishes. However, adult returns are expected to improve somewhat in 2020 (due to recent resolution of the hatchery issues and improved ocean conditions).

The recovery plan for SR sockeye salmon (NMFS 2015c) identified many limiting factors negatively affecting the ESU's spawning, incubating, and rearing habitat, as well as the migratory corridor from the Sawtooth Valley to the ocean: natal lake habitat, mainstem Salmon River habitat, Lower Snake River habitat (upstream of Lower Granite reservoir), mainstem CRS migration corridor (lower Snake and lower Columbia Rivers), estuary habitat, hatcheries, harvest, and predation. Tributary habitat improvements implemented by Federal, tribal, state, local, and private entities are likely improving habitat conditions to some extent for SR sockeye salmon in the Salmon River basin where juveniles migrate. However, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of SR sockeye salmon.

SR sockeye salmon must pass eight mainstem dams on the lower Snake and lower Columbia rivers to reach the ocean and return to their spawning grounds. Juveniles predominantly out-migrate in May and early June in the lower Snake and lower Columbia Rivers. Adults predominantly migrate upstream through this reach in June and July, arriving in the Sawtooth Basin in August and September. Conditions for juvenile SR sockeye salmon have generally improved in the lower Snake and lower Columbia Rivers because of the installation and operation of surface passage routes, 24-hour spill, improved spill patterns, and improvements to the juvenile bypass systems at the mainstem dams. Excluding 2011 (when no survival estimate could be made) and 2016 and 2017 (which were compromised by the Springfield Hatchery issues), Lower Granite to Bonneville Dam survival rates for hatchery and natural-origin SR sockeye salmon vary substantially (37 to 71 percent) but have averaged about 56 percent the past 10 years (2010 and 2019, excluding 2011 [no data] and 2016 to 17 [poor quality hatchery fish]) (Zabel 2019, Widener et al. 2020).

The juvenile survival rates from Lower Granite Dam to Bonneville Dam include all sources of mortality, even those that are not caused by the past or proposed operation and maintenance of the CRS. For instance, regardless of the operational and configurational choices made for the hydrosystem, some predation and other natural mortality of juvenile SR sockeye salmon would occur during their migration. In addition, juvenile survival is influenced by past and present alterations of shoreline habitat, among other stressors, unrelated to the effects of operating the hydrosystem; many of those effects will continue into the future. We are unable to differentiate the proportion of the losses that result from the operation and maintenance of the mainstem dams rather than to the existence of the dams, but we know that the mortality attributable to operations and maintenance is less than the losses captured in the overall survival estimates. As discussed further below, some also hypothesize that passage through juvenile bypass systems and turbines causes latent mortality, which would not be captured in the direct survival estimates.

Juvenile sockeye salmon are transported from Lower Granite, Little Goose, and Lower Monumental Dams. Transportation rates have averaged about 43 percent (2013 to 2019). T:B ratios (Lower Granite to Lower Granite SARs of transported smolts compared to bypassed smolts migrating in 2009 and 2011 to 2014, when adequate numbers of PIT tagged adult returns were available to make estimates) were about 1.40 (geometric mean), meaning that transportation generally benefits juvenile sockeye (increases adult returns) compared to smolts that were bypassed back to the river to continue migrating. The ratios include the higher adult straying rates and lower adult survival rates associated with transportation between Bonneville and Lower Granite dams. We expect that the juvenile monitoring associated with the adaptive management program will ensure that transport will continue to provide benefits to SR sockeye salmon and be responsive to potential future changes in juvenile migration timing.

Excluding 2015, recent adult survival rate estimates for SR sockeye salmon have averaged about 77 percent from Bonneville to McNary Dam (2010 to 2019), about 89 percent from McNary to Lower Granite Dams (2010 to 2017) and 65 percent from Bonneville to Lower Granite Dams (2010 to 2017).[159] In 2015, due to unprecedented early high water temperatures that persisted throughout the summer in the Columbia River basin, only 15 percent of adult SR sockeye salmon survived from Bonneville to McNary Dam and only 4 percent survived from Bonneville to Lower Granite Dam. It is uncertain how frequently similar conditions might occur in the future, though it will certainly be more often than in the past (one event since 1938). Lower Granite and Little Goose Dams have been equipped with cool-water "showers" to reduce temperature differentials within the adult fish ladders and in the forebay at the ladder exits to reduce delays and potentially improve adult survival rates. These structures, and the continued use of Dworshak Dam to cool lower Snake River temperatures, should not only maintain, but improve adult passage conditions at the Snake River Projects.

Consistent with NMFS' recommendations in the 2016 Adult Sockeye Report (NMFS 2016a), the Corps has greatly expanded its temperature monitoring capabilities in the fishways of the mainstem Snake and Columbia River dams. Based on these improved data, specific ladders will be evaluated to determine if structures similar to those designed and installed at Lower Granite and Little Goose Dams might be effective at reducing temperature differentials within the fishways. NMFS expects that this process will likely improve adult passage conditions at some dams in the lower Columbia River. However, even with these improvements, if the temperatures experienced in June and July of 2015 were to recur, they would likely result in similarly low survival rates, especially in the Bonneville to McNary Dam reach, where the great majority of sockeye salmon perished.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Very few adult and juvenile Snake River sockeye salmon are likely to be affected by these activities

[159] Too few PIT tags were detected in 2018 and 2019 to make valid adult survival estimates for SR sockeye salmon. Upper Columbia stocks of adult sockeye were used as a surrogate estimate for SR sockeye salmon from Bonneville to McNary Dam).

because they are not typically migrating during the period of time when these activities are typically scheduled. Non-routine and unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the inseason adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative spill or turbine unit priorities) will likely minimize these impacts.

The proposed spring spill levels would implement a program of voluntary fish passage spill with the highest spill volumes ever implemented. This will increase juvenile exposure to higher TDG levels; however, it is unlikely that spilling up to 125 percent TDG for 16 hours per day at mainstem dams[160] will result in any substantial, negative impacts to juvenile survival (or adult passage, for those individuals migrating upstream prior to June 21) because there are sufficient data and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). The proposed 125 percent flexible spill operation could improve direct juvenile survival rates through the four lower Snake and four lower Columbia river mainstem projects (with the possible exception of Bonneville Dam, where survival rates could decrease slightly, and at The Dalles Dam, which will maintain spill levels of 40 percent). Fewer than half of the adults would pass Bonneville Dam before the end of spring spill operations on June 20, so the majority of adults should be l unaffected by the higher spill levels. The CSS model predicts substantial juvenile survival increases for Snake River spring-summer Chinook salmon and steelhead, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillbays) will increase adult returns by about 35 and 28 percent, respectively. If these predictions are realized and if SR sockeye salmon are benefited in a similar fashion (though CSS has never presented a hypothesis for sockeye), they would represent a substantial near term improvement in productivity and abundance for SR sockeye (see NMFS' life-cycle modeling for SR spring-summer Chinook salmon), and, over time, would reduce the severity of expected declines in abundance and productivity caused by warming climate and deteriorating ocean conditions.

The quality of rearing habitat in Redfish, Pettit, and Alturas Lakes are thought to be supportive of spawning and rearing sockeye salmon. Substantial losses of both juvenile and adult migrants have been documented between these lakes and Lower Granite Dam. While the cause of these losses is unknown, they indicate that migration corridor habitat is likely degraded by several factors (e.g., water diversions, reduced flows, increased predation, increased summer temperatures) and will continue to negatively affect SR sockeye salmon abundance and productivity. The proposed action does not propose specific habitat improvement actions to benefit SR sockeye salmon, but actions taken for SR spring/summer Chinook salmon and

[160] Except at John Day Dam, The Dalles, and Bonneville Dam, where proposed spill operations are limited to 120 percent TDG, 40 percent spill, and 150 kcfs, respectively.

steelhead in the upper Salmon River (e.g., screening water diversions, increasing flows, or reducing summer temperatures), to the extent they affect the migration corridor, would be expected to provide some small benefit to migrating SR sockeye salmon.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing condition. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving SR sockeye salmon abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity and life-history diversity) for this ESU. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies' propose to continue implementing the Caspian Tern Nesting Habitat Management Plan, the Double-crested Cormorant Management Plan, and the IAPMP, as well as hazing at the mainstem dams. For SR sockeye salmon, we expect that management of the tern colonies throughout the basin is reducing mortality by a small amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that prey on sockeye salmon are also present in the hydrosystem reach. Increasing the John Day reservoir elevation in the spring should control impacts from the Blalock Islands tern colony. The NPMP and dam angling program are expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested Cormorant Management Plan, these programs will maintain current (reduced) levels of predation, creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Upstream migrating sockeye salmon are likely encountering outmigrating California sea lions and Steller sea lions as they move toward breeding grounds outside of the Columbia River basin. There are no estimates for the proportion of sockeye salmon that are consumed by pinnipeds in the Columbia River; however, the overall impact of pinniped predation on salmon is likely related to overall pinniped abundance and there is some evidence that recent increases in pinniped abundance in the Columbia River have likely resulted in increased predation of sockeye salmon in recent years. Numbers during June when sockeye salmon are migrating have increased substantially in recent years, from about 45 pinnipeds in 2008 to 2009 to over 500 in 2014 to

2017. Sea lion predation downstream of Bonneville Dam, including the estuary, likely continues to negatively affect the productivity and abundance of SR sockeye salmon.

The past effect of artificial production programs has largely been to preserve genetic resources and increase abundance to support reintroduction efforts into Redfish Lake, Pettit Lake, and Alturas Lakes. Excepting poor survival, apparently stemming from differential water hardness, affecting the 2015 to 2017 hatchery releases from the Springfield Hatchery, the hatchery programs have been very successful and the number of juvenile outmigrants has continued to increase. However, these programs have also posed risks to natural productivity and genetic diversity. The continued operation of the hatchery programs should limit genetic risks while providing increased abundance to support the establishment of natural spawning populations in the three targeted lakes. Reestablishing naturally producing populations in additional lakes will increase the abundance, productivity, distribution and genetic diversity of the SR sockeye salmon ESU.

The largest harvest-related effects on SR sockeye salmon result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery, and estimates that reported harvest rates should continue in the range of 6 to 8 percent, depending on run size. However, based on PIT-tag-based survival estimates, substantial losses are occurring between Bonneville and McNary Dams. Fallback and straying have been ruled out because they affect too few fish to account for the losses. In some years, high temperatures and associated disease and stress likely contribute substantially to adult losses, but in others, there is little or no indication of this source of mortality. Harvest managers will continue to evaluate this issue (lower observed PIT-tag survival rates in the lower Columbia River for SR sockeye salmon) within the *U.S. v. Oregon* Technical Advisory Committee.

As described in Section 2.4.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area considered for SR sockeye salmon are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect SR sockeye salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of SR sockeye salmon as very high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change. However, the severity of those changes could be reduced as a result of the proposed action.

Clearly, losses in the lower Columbia River resulting from exceptionally high June temperatures in 2015 indicate that adult SR sockeye salmon are particularly sensitive to high summer temperatures; and these conditions are likely to occur with increased frequency in the future. Over time, summer migrating adults could potentially respond temporally to changing

Climate change is a substantial threat to SR sockeye salmon, especially during the marine rearing phase and adult migration phase of their life cycle. The proposed action is expected to reduce, to some limited extent, both the scope and severity of those impacts and not exacerbate them. The proposed action therefore is expected to slightly increase the resiliency of the populations to climate change and provide time for additional recovery actions to be implemented.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of SR sockeye salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of SR sockeye salmon.

2.4.5.2 Critical Habitat

Designated critical habitat for SR sockeye salmon includes all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to the Snake River, the mainstem Snake River upstream to the Salmon River, the Salmon River upstream to Alturas Lake Creek and Stanley, Redfish, Yellow Belly, Pettit, and Alturas Lakes, and the portion of Valley Creek between Stanley Lake Creek and the Salmon River. Across subbasins with PBFs for SR sockeye salmon in the Interior Columbia Recovery Domain, widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas, riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened. An important exception is that the natal lakes in the Sawtooth Valley are in relatively good condition due to functioning habitat in large portions of their contributing watersheds. This is associated with recreational, wilderness (i.e., roadless), and similar land use designations. In addition, local recovery actions have restored access to multiple historical spawning areas as well as improved conditions along the shorelines of these lakes.

The environmental baseline also includes a broad range of past and present actions and activities, including effects of the hydrosystem, that have affected the conservation value of critical habitat in juvenile and adult migration corridors for SR sockeye salmon. Some of these past effects will continue under the proposed action: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and passage delays (reduction in safe passage). These factors have increased the likelihood of excessive predation on juvenile SR sockeye salmon and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The proposed action carries forward structural and operational improvements since 2008 that address these effects on PBFs and in some cases, improves upon them. The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors.

The Action Agencies also have reduced effects of their operations on juvenile salmonid travel time and survival by increasing levels of spring spill. We expect the additional flexible spring spill to 125 percent TDG to reduce water quality in the juvenile and adult migration corridors by a small amount while having a small positive effect on safe passage at CRS projects in the lower Snake and Columbia Rivers through increased spillway passage. Although higher spring spill levels could degrade tailrace conditions for juvenile migrants at Lower Granite, Little Goose, Lower Monumental, and John Day Dams, increasing the risk of bird and fish predation, there is sufficient flexibility through the in-season management process to identify and remedy negative effects through modified spill patterns. The spring spill operation will have a small negative effect on water quality and safe passage for adult sockeye salmon that arrive at Bonneville Dam before mid-June.

Operating turbines above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults while improving attraction to the adult fishways (increase in safe passage). However, by increasing powerhouse flows, it will decrease safe passage by a small amount because some adults will fall back and some juveniles will pass downstream through turbines or bypass systems.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have very small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors.

In summary, the proposed action is not likely to further limit water quantity or water quality or to reduce safe passage in the juvenile or adult migration corridors by a meaningful amount. In addition, if the CSS hypothesis regarding latent mortality in spring Chinook salmon is correct, and if SR sockeye are similarly affected, the flexible spill program could improve the functioning of the juvenile migration corridor to a much greater extent than indicated by the likely effects on safe passage described above.

Increasing the elevation of John Day Reservoir to cover nesting areas on the Blalock Islands will limit the risk of predation by Caspian terns by delaying nesting until about 95 percent of steelhead outmigrants have passed McNary Dam, which will also protect most juvenile SR sockeye salmon. The Action Agencies also will continue to implement measures to reduce pinniped predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the hydrosystem and the estuary, and the predation management programs for Caspian terns on the interior plateau and for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will reduce or maintain the levels of predation within the juvenile and adult migration corridors that were achieved in recent years, although cormorant predation rates may increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. The Action Agencies' proposed estuary habitat program will continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling sockeye salmon migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of SR sockeye salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of SR sockeye salmon designated critical habitat.

2.4.6 Conclusion

After reviewing and analyzing the current status of SR sockeye salmon and critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SR sockeye salmon or destroy or adversely modify its designated critical habitat.

2.5 Snake River (SR) Fall Chinook Salmon

This section applies the analytical framework described in Section 2.1 to the SR fall Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the SR fall Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.5.1 Rangewide Status of the Species and Critical Habitat

The status of the SR fall Chinook salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.5.1.1 Status of Species

2.5.1.1.1 Background

On April 22, 1992, NMFS listed the SR fall Chinook salmon ESU as a threatened species (57 FR 14653). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and again on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that this ESU should retain its threatened status (81 FR 33468). Critical habitat was originally designated on December 28, 1993 (58 FR 68543). The summary that follows describes the status of SR fall Chinook salmon. Additional information can be found in the recovery plan (NMFS 2017h) and the most recent status review for this species (NMFS 2016b).[161]

The SR fall-run Chinook salmon ESU includes one MPG with one extant population: the Lower Mainstem Snake River population, which includes all natural-origin fall-run Chinook salmon originating from the mainstem Snake River below Hells Canyon Dam and from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins (NMFS 2017h). Fall-run Chinook salmon from four artificial propagation programs are also included in this ESU—the Lyons Ferry Hatchery Program, the Fall Chinook Acclimation Ponds

[161] In addition, a technical memo prepared for the status review contains more detailed information on the biological status of the species (NWFSC 2015).

Program, the Nez Perce Tribal Hatchery Program, and the Oxbow Hatchery Program (now referred to as the Idaho Power Program (NMFS 2017h, 70 FR 37160).[162]

Historically, another large population of fall-run Chinook salmon also spawned above the Hells Canyon Dam Complex (NMFS 2016b, 2017h). This population was extirpated in the early 1960s after the construction of the Hells Canyon Dams (Figure 2.5-1). The extant, ESA-listed population occupies a geographically large and complex area with five major spawning groups: 1) Upper Hells Canyon, 2) Lower Hells Canyon, 3) Clearwater River, 4) Grande Ronde River, and 5) Tucannon River.

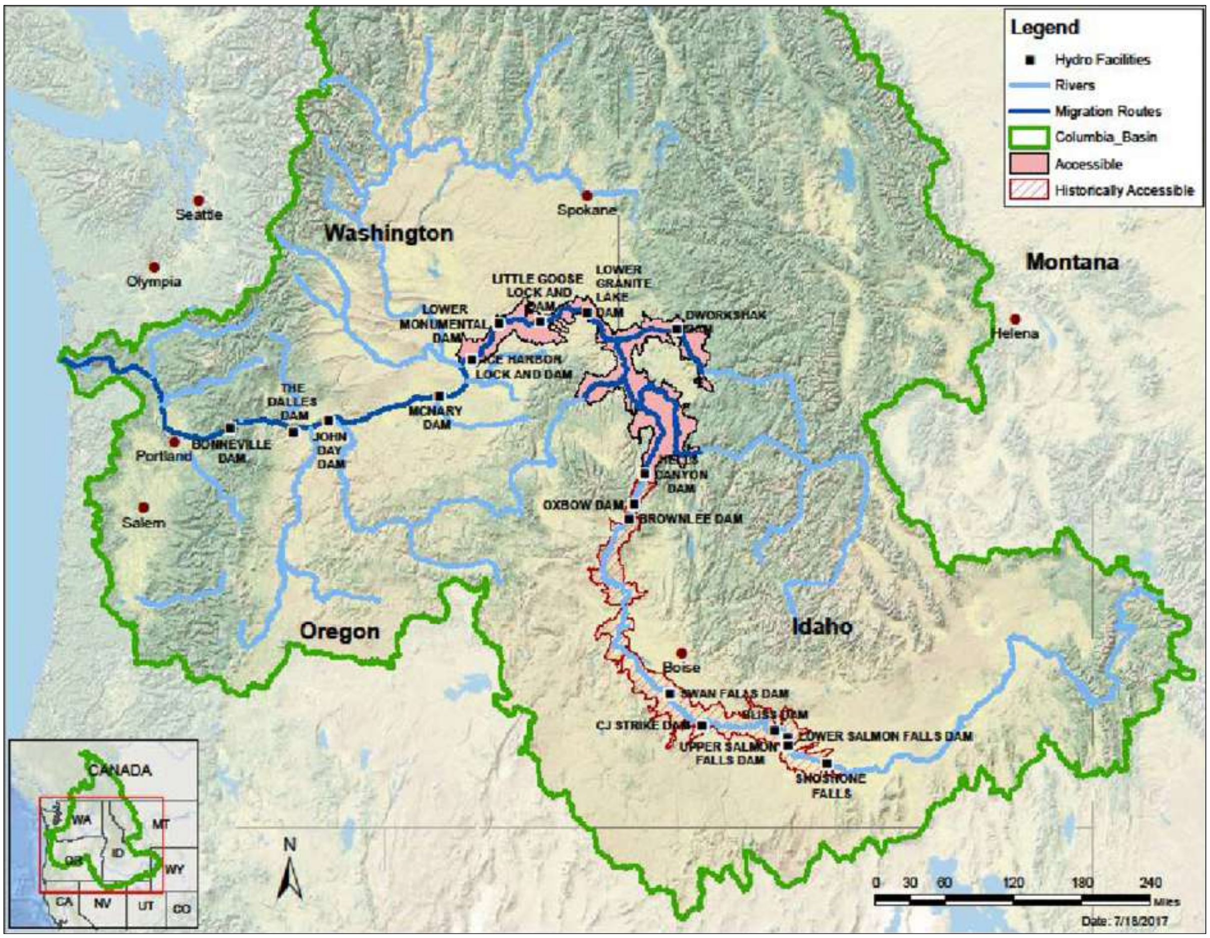

Figure 2.5-1. Map of the SR fall Chinook salmon current and historical spawning range. The areas shaded pink denote habitat that is currently occupied; the red hatched areas denote habitat that was accessible historically, but is now blocked by the Hells Canyon Project and other dams on the mainstem Snake River. Source: NMFS 2017h.

[162] For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including SR fall Chinook salmon (81 FR 72759). The proposed changes for hatchery programs in this ESU were to change the name of the Oxbow Hatchery Program to the Idaho Power Program. We expect to publish the final revisions in 2020.

2.5.1.1.2 Life History and Factors for Decline

Most SR fall Chinook salmon production historically came from large mainstem reaches that supported a subyearling, or "ocean-type," life history strategy. Adults migrated up the Columbia and Snake Rivers from July to August through November and spawned from late September to early October through November. Eggs developed rapidly in the relatively warm lower mainstem reaches of several tributary rivers, which facilitated emergence during late winter and early spring and accelerated growth such that juveniles could become smolts and migrate to the ocean in May and June (NMFS 2017h). This life history strategy allowed fall Chinook salmon to avoid high summer temperatures and losses associated with over-summering and over-wintering that affect other Chinook salmon ESUs with a yearling, or "stream-type," life history strategy.

At present, the subyearling life history strategy contributes most of the natural-origin adult returns to the ESU, and the timing of adult migration and spawning plus egg incubation, fry emergence, and juvenile emigration is similar to historical patterns. However, a yearling life history strategy is also supported, mostly for juveniles from the cooler Clearwater River subbasin,[163] which overwinter in the lower Snake River reservoirs or other cool-water refuge areas and migrate downstream the following spring (NMFS 2017h).

Multiple factors were responsible for the decline of SR fall Chinook salmon. First, they were harvested at very high rates starting in the 1880s, and continuing through the 1980s. Second, the development of mainstem dams in the middle Snake River from the 1900s to the 1960s (Swan Falls Dam, the Hells Canyon Complex of dams, and others) inundated and blocked access to the most productive spawning and rearing habitat, eliminated one of the two large populations that existed historically, and affected water quality. The construction of Lewiston Dam on the Clearwater River blocked access to upstream habitat there starting in 1927, and extirpated fall Chinook salmon within that subbasin. Third, the development of mainstem dams in the lower Snake and Columbia Rivers (1938 to 1975) greatly altered mainstem migration and rearing habitat, affected the survival of juvenile and adult migrants, and affected water quality (increased TDG levels, altered thermal regime, decreased sediment transport, etc.). Fourth, the construction and operation of dams and water conveyance systems for irrigation and other purposes (starting in the late 1800s) substantially affected seasonal flows in the mainstem Snake and Columbia Rivers and the Columbia River estuary and plume. Fifth, land use practices (agriculture, grazing, mining, timber harvest, etc.) negatively affected important water-quality parameters (nutrients, fine sediments, toxic contaminants) and channel complexity, especially in the middle Snake River[164] and the lower reaches of the five Snake River tributaries used for spawning and rearing.

[163] Cool water has been released from Dworshak Dam since the mid-1990s to reduce summer temperatures that can impair passage conditions for migrating adult salmon and steelhead. This action retards the growth and delays the migration of juveniles rearing in the Clearwater River in July and August, but maintains thermal conditions, especially in Lower Granite, Little Goose, and Lower Monumental Reservoirs that allow juvenile Chinook to survive the summer and early-fall periods, overwinter, and migrate the following spring.

[164] Currently, water quality in the middle Snake River is highly degraded (excessive nutrients, excessive algal growth, anoxic or hypoxic conditions in spawning gravels, and increased sediment loads) and not sufficient to support fall Chinook salmon production.

Lastly, strays from non-Snake-River-origin hatcheries on the spawning grounds posed a serious threat to the genetic integrity of the species (Waples et al. 1993; NMFS 2016b, 2017h).

These factors substantially reduced the amount and quality of available spawning, rearing, and migration corridor habitat; reduced the productivity of SR fall-run Chinook salmon in all freshwater life history stages; and resulted in extremely low abundance by 1990, when only 78 naturally produced adults were counted passing Lower Granite Dam.[165]

While some of the threats that contributed to the original listing of SR fall Chinook salmon continue, many actions have been taken to reduce threats and improve SR fall Chinook salmon survival and the conservation value of the habitat upon which they depend. While still substantial, overall harvest rates have been reduced from around 60 to 80 percent as recently as the 1980s to 40 to 50 percent since the mid-1990s as a result of reduced ocean harvest and the use of abundance-based “sliding scales” to manage fisheries in the mainstem Columbia River. These actions have improved the productivity and abundance of the single population by increasing the number of adult fall-run Chinook salmon returning to the spawning areas (NMFS 2016b, 2017h).

Starting in the late 1990s, large numbers of hatchery-produced fish—up to 5.5 million annually—began to be released. These programs have substantially improved the abundance of SR fall Chinook salmon in spawning areas upstream of Lower Granite Dam. The progeny of hatchery fish spawning in the wild are considered natural-origin when they return to spawn, so these fish contributed to the rapid rebuilding of the ESU. However, NMFS (2016b) noted concerns that continued high levels of hatchery-origin fish on the spawning grounds could pose a risk to long term population diversity and productivity.

Since 1992, Idaho Power Company has operated the Hells Canyon Complex of dams to provide stable spawning and incubation flows in the upper Hells Canyon reach of the Snake River for SR fall Chinook salmon. These flows ensure that redds are not dewatered during winter load-following operations (i.e., daily and hourly flow fluctuations). This voluntary action has likely improved egg-to-fry survival, although some negative effects on habitat quality remain (Section 2.5.2.4). The Action Agencies have also taken many structural and operational measures at CRS projects to improve conditions for SR fall Chinook salmon since the ESA listing in 1992 (NMFS 2017h).

2.5.1.1.3 Recovery Plan

The ESA recovery plan for SR fall Chinook salmon (NMFS 2017h) includes delisting criteria for the ESU, along with identification of factors currently limiting its recovery, and management actions necessary to achieve the goals. Biological delisting criteria are based on

[165] This compares to an estimated historical average of about 500,000 returning adults (NMFS 2017h).

recommendations by the ICTRT.[166] They are hierarchical in nature, with ESU-level criteria based on the status of natural-origin SR fall Chinook salmon assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the ESU will require sufficient improvement in its abundance, productivity, spatial structure, and diversity.

The recovery plan considered three potential recovery scenarios (including two single-population scenarios and one that would require recovering the extirpated population above the Hells Canyon Dam complex). It identified the single-population scenario aimed at achieving highly viable status (50 percent probability of a less than 1 percent risk of extinction in 100 years) for the extant population and evaluating the status of the population based on natural productivity in one or two "natural production emphasis areas" as the most likely scenario to achieve recovery. The relatively low hatchery contributions targeted in the natural production emphasis area(s) would provide "an opportunity to gain more direct information on intrinsic productivity without the masking effect common when high levels of hatchery-origin spawners are present" (NMFS 2017h).

2.5.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within the ESU based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the ICTRT. Delisting criteria define parameters for individual population status as well as for how many and which populations must achieve a particular status for each MPG to be considered at low risk. Generally, each MPG must achieve low risk for the ESU as a whole to be considered no longer threatened or endangered.

As of the most recent status review (NWFSC 2015, NMFS 2016b), the extant Lower Mainstem SR fall Chinook salmon population was considered viable (i.e., at low risk of extinction), an improvement from its moderate risk rating in the previous status review but below the recovery plan goal of high certainty of highly viable status (i.e., very low extinction risk). This risk rating was based on a low risk rating for abundance/productivity and a moderate risk rating for spatial structure/diversity (NWFSC 2015).

The 10-year geometric mean in natural-origin abundance for spawner escapement for the years 2005 to 2014 was 6,418. This geometric mean exceeded the buffer for statistical uncertainty in estimated abundance in the recovery plan. The associated productivity estimates, however, were below the recovery plan requirements, and reflected uncertainty due to the high numbers of

[166] The recovery plan also includes "threats criteria" for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

hatchery-origin fish on the spawning grounds. The status review also noted uncertainty about whether the recent increases in abundance (which were driven largely by relatively high escapements in the last 3 years of that review period) could be sustained over the long run (NWFSC 2015, NMFS 2016b).

The moderate risk rating for spatial structure/diversity was driven by changes in major life history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity in samples from natural-origin returns. The rating also reflected risk associated with the high levels of hatchery-origin spawners in natural spawning areas and the potential for selective pressure imposed by current hydropower operations and cumulative harvest impacts. To achieve delisting goals, the spatial structure/diversity rating needs to be at low risk (NWFSC 2015).

The most recent status review (NWFSC 2015, NMFS 2016b) noted that to achieve the abundance/productivity risk rating consistent with the proposed delisting criteria, an increase in estimated productivity (or a decrease in the year-to-year variability associated with the estimate) would be required, and natural-origin abundance of the extant population would need to remain relatively high. An increase in productivity could occur with a further reduction in mortalities across life stages. It is also possible that survival improvements resulting from actions in recent years (e.g., more consistent flow-related conditions affecting spawning and rearing, and increased passage survivals resulting from expanded spill programs) have increased productivity, but that due to sustained recent high abundances, we have not been able to measure the intrinsic productivity of the population (which measures productivity at low abundances and is the metric recommended by the ICTRT). A third general possibility is that productivity may be decreasing over time as a result of negative impacts of chronically high hatchery proportions across natural spawning areas. Such a decrease would also be largely masked by the high annual spawning levels (NWFSC 2015, NMFS 2016b).

2.5.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect SR fall Chinook salmon provides important information and perspective regarding the status of the species. One of the necessary steps in achieving species' recovery and delisting is to ensure that the underlying limiting factors and threats have been addressed. Limiting factors and threats identified in the recovery plan (NMFS 2017h) for this ESU include (in no particular order):

- Blocked habitat: The Hells Canyon Complex of dams (and five additional upstream Snake River dams) blocks access to 80 percent of the historical spawning habitat for SR fall Chinook salmon, including the habitat that was historically the most productive.[167]
- Hydropower: Operation of the Hells Canyon Complex dams has altered flows, sediment transport, and the thermal regime of the Lower Snake River, resulting in altered migration patterns, juvenile fish stranding, and entrapment. Idaho Power Company

[167] Currently, however, the mainstem habitat in the blocked area is too degraded to support significant fall Chinook salmon production.

reduces these effects by providing stable flow from Hells Canyon Dam during the fall Chinook salmon spawning season to support incubating eggs and emerging fry. In addition, eight CRS projects (four on the lower Snake River and four on the Columbia River) adversely affect passage for juveniles and adults.

- Tributary habitat: Although SR fall Chinook salmon spawn primarily in the mainstem Snake River, they also spawn in lower reaches of tributaries to the Snake River, where lack of habitat complexity, excess fine sediment, degraded riparian conditions, low summer flows, and water quality (high summer water temperatures, low dissolved oxygen, and nutrients) are of some concern.
- Estuary: SR fall Chinook salmon subyearling migrants that access and use shallow, nearshore areas and other floodplain habitats are affected by reduced estuarine habitat as a result of changes in sediment/nutrient levels and flow, reduced floodplain connectivity, increased water temperature, changes in food sources, altered predator/prey relationships, and exposure to toxic contaminants.
- Harvest: SR fall Chinook salmon encounter fisheries in the ocean, in the mainstem Columbia River, and in some tributaries. Fisheries do not directly target ESA-listed natural-origin fall Chinook salmon. Instead they target marked hatchery fish (fall Chinook salmon and other species) and non-listed natural fish (fall Chinook salmon and other species).While the recovery plan noted that the total exploitation rate on SR fall Chinook salmon had declined significantly since ESA listing, it also noted the direct and indirect effects of harvest as a concern.
- Hatcheries: At one time, out-of-ESU hatchery programs were a major concern because the returning adult fish strayed into the Snake River and spawned naturally. Strays from out-of-ESU programs have since been reduced substantially. Within-ESU hatchery programs have reduced short-term risk to SR fall Chinook salmon by increasing abundance and spatial structure, but the size of the programs relative to the level of natural-origin production and consequent high proportion of hatchery-origin fish on the spawning grounds raises concerns about natural-origin productivity and diversity.
- Predation: In general, rates of predation by birds on SR fall Chinook salmon are relatively low. California sea lions that gather at Bonneville Dam have generally left the area by the time of the fall Chinook salmon migration. However, the number of Steller sea lions in the area has increased since 2011, and they are assumed to prey on adult SR fall Chinook salmon, although the level of predation is not known. Both native and non-native fish prey on fall Chinook salmon.
- Additional factors include exposure to toxic contaminants, and the effects of climate change and ocean cycles.

In its most recent status review, NMFS (2016b) noted that:

- Abundance in the extant SR fall Chinook salmon population had increased substantially since listing. This increase was attributed to a combination of actions that enhanced spawning and incubation conditions below Hells Canyon Dam, improved survival through the hydropower system, reduced harvest, and increased natural production through hatchery supplementation.

- Improvements had been made in tributary and estuary habitat conditions due to restoration and protection efforts, but habitat concerns remain throughout the Snake River basin, particularly in regard to streamflow, floodplain management, and water temperature.
- Changes to hydropower operations and passage had increased juvenile survival rates.
- The adoption of the 2008 to 2017 *U.S. v. Oregon* Management Agreement had, on average, reduced impacts of freshwater fisheries to all Snake River ESUs/DPSs.
- SR fall Chinook salmon hatchery production levels had increased since the previous review. Considerable uncertainty existed about the effect of SR fall Chinook salmon hatchery programs on the extant population.
- New information indicated that avian and pinniped predation had increased since the previous status review, although it was not possible to quantify the change or impact on SR fall Chinook salmon.
- Regulatory mechanisms had in general improved since the previous status review.
- Uncertainty regarding the long-term impacts of climate change and the ability of SR fall Chinook salmon to adapt added additional risks to species recovery.

2.5.1.1.6 Information on Status of the Species since the 2016 Status Review

The best available scientific and commercial data available with respect to the adult abundance of SR fall Chinook salmon indicates a substantial downward trend in the abundance of natural-origin spawners at the ESU level from 2013 to 2019 (Figure 2.5-2). The recent downturn is thought to be driven primarily by marine environmental conditions and a decline in ocean productivity (see discussion below), because hydropower operations and hatchery practices have been relatively constant or improving over the past 10 years. Even with this decline, overall abundance has remained higher than before 2005.

The SR fall Chinook salmon ESU is composed of a single demographically independent population. Five-year geometric means in the numbers of natural-origin and total (natural- plus hatchery-origin) spawners through 2018 are shown in Table 2.5-1. These indicate very small negative changes in abundance between the two most recent 5-year periods.[168] This ESU appears to be less negatively affected by ocean conditions than SR spring/summer Chinook salmon (Section 2.2.2.1.6).

[168] The upcoming status review, expected in 2021, will include population-level adult returns through 2019, and will add a new rolling 5-year geomean, for 2015-2019. Because the adult return in 2014 was higher than in subsequent years, the negative percent change between the 2015-2019 and 2014-2018 geomeans will likely be greater than that shown in Table 2.5-1 between the 2014-2018 and 2009-2013 geomeans.

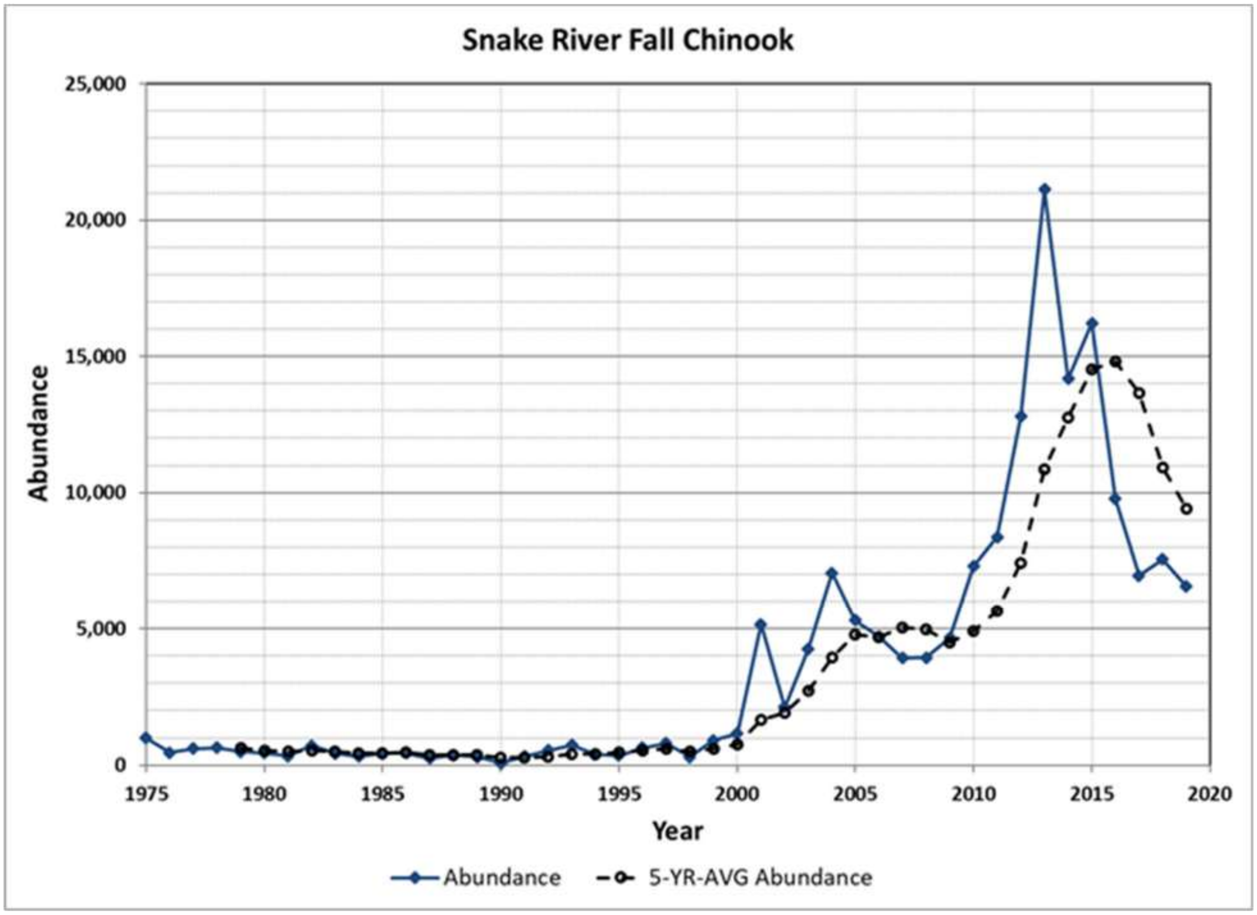

Figure 2.5-2. Annual abundance and 5-year average abundance estimates for the SR fall Chinook salmon ESU (natural-origin fish only) at Lower Granite Dam from 1975 to 2019. Data from 1975 to 2018 are from the 2019 Joint Staff Report on Stock Status and Fisheries (WDFW and ODFW 2019). The 2019 estimate is from the Nez Perce Tribe (Hesse 2020).

Table 2.5-1. 5-year geometric mean of natural-origin spawner counts for SR fall Chinook salmon. Number in parenthesis is the 5-year geometric mean of total spawner counts. "% change" is between the two most recent 5-year periods (2014-2018 compared to 2009-2013). At the time of drafting this opinion, 2019 data were not available for this ESU. Source: Williams (2020a).

Population	MPG	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change
Snake River Mainstem	Lower Mainstem Snake River	313 (597)	467 (785)	2083 (5513)	3930 (10002)	8985 (31327)	8809 (30364)	-2 (-3)

NMFS will evaluate the implications for viability risk of these more recent returns in the upcoming 5-year status review, expected in early 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.5-1.

Since the status review in 2016, observations of coastal ocean conditions suggested that recent outmigrant year classes have experienced below-average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict the drop in adult Chinook salmon returns observed through 2019 (Werner et al. 2017). Some of the negative impacts on juvenile salmonids had subsided by spring 2018, but other aspects of the ocean ecosystem (e.g., temperatures below the 50-meter surface layer) had not returned to normal (Harvey et al. 2019). Expectations for marine survival are relatively mixed for juveniles that reached the ocean in 2019 (Zabel et al. 2020).

2.5.1.2 Status of Critical Habitat

NMFS designated critical habitat for SR fall Chinook salmon to include all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to the Snake River confluence, as well as all river reaches of the mainstem Snake River upstream to Hells Canyon Dam, the Palouse River from its confluence with the Snake River upstream to Palouse Falls; the Clearwater River from its confluence with the Snake River upstream to its confluence with Lolo Creek, and the North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam. Critical habitat also includes river reaches presently or historically accessible (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams) to SR fall Chinook salmon in the Clearwater, Hells Canyon, Imnaha, Lower Grande Ronde, Lower North Fork Clearwater, Lower Salmon, Lower Snake, Lower Snake-Asotin, Lower Snake-Tucannon, and Palouse subbasins (50 CFR 226.205(c)). The mainstem Columbia and Snake River migration corridor is among the areas of high conservation value to the ESU because it connects the single extant population with the ocean and is used by rearing and migrating juveniles and migrating adults.

The PBFs identified when critical habitat was designated are essential to the conservation of SR fall Chinook salmon because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, and migration, and foraging). For example, the PBFs of freshwater spawning and rearing areas for SR fall Chinook salmon include spawning gravel, water quality and quantity, water temperature, food, riparian vegetation, and space (Table 2.5-2).

Table 2.5-2. Physical and biological features (PBFs) of critical habitats designated for SR fall Chinook salmon and components of the PBFs. NMFS (1993) did not identify specific areas for growth and development to adulthood in the ocean.

Physical and Biological Features	Component of the PBF
Spawning and juvenile rearing areas	Spawning gravel Water quality Water quantity Cover/shelter Food Riparian vegetation Space
Juvenile and adult migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food (juvenile migration corridors) Riparian vegetation Space Safe passage
Areas for growth and development to adulthood	Ocean areas – not designated

The complex life cycle of SR fall Chinook salmon gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead rely on limited stored energy to migrate, mature, and spawn. Like juveniles, the returning adults require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle.

In the following sections we discuss the status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary Recovery Domains.

2.5.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia Recovery Domain, which includes the Snake River basin, for SR fall Chinook salmon. The value of PBFs in the upper Hells Canyon reach (spawning and rearing), and to a lesser extent in the lower Hells Canyon reach, has been greatly improved by Idaho Power Company's voluntary implementation of a fall Chinook salmon flow program, which provides stable spawning and incubation flows from October to

March, and the Juvenile Fall Chinook Salmon Entrapment Management Plan, with operations to reconnect high-priority entrapment sites to the river for at least 2 hours each day. However, elevated levels of nutrients entering Brownlee Reservoir are associated with low dissolved oxygen levels in the late summer and fall in the water discharged from Hells Canyon Dam into SR fall Chinook salmon spawning and incubation habitat downstream. Water that is discharged into the occupied reach is warmer than under historical conditions, and combined with the concentrations of toxic contaminants, negatively affects water quality in spawning and rearing areas (NMFS 2017h).

The functioning of critical habitat in the other major spawning and rearing areas is primarily affected by loss of habitat complexity and connectivity, reduced late summer/fall flows, water-quality issues, toxic contaminants, and predation by both native and nonnative predators. Spawning habitat in the lower Clearwater River is negatively affected by high TDG levels during winter and spring spill events at Dworshak Dam (NMFS 2017h).

Construction of large hydropower and water storage projects associated with the CRS affected salmonid migratory conditions and survival rates. As noted above, the production of SR fall Chinook salmon was especially impacted by the development of eight major Federal dams and reservoirs in the mainstem lower Columbia/Snake River migration corridor between the late 1930s and early 1970s. All eight dams provide fish passage, but fish survival and productivity is affected by their operations and configurations (NMFS 2017h). Hydrosystem development modified natural flow regimes, resulting in warmer late summer/fall water temperatures. Changes in fish communities led to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines and juvenile bypass systems, have also killed some outmigrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented improvements in the juvenile and adult migration corridors, including volitional spill, improved surface passage routes, improved juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

Many stream reaches designated as critical habitat are listed on the Oregon and Washington Clean Water Act Section 303(d) lists for water temperature. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures (Spence et al. 1996). Furthermore, contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste are common in some areas of critical habitat. They can negatively impact critical habitat and the organisms associated with these areas.

2.5.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat has also been designated for SR fall Chinook salmon in the lower Columbia River estuary. For the purpose of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained the dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed that restrict the position of tributary confluences. Over time, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). Dampening of the historical variability in mainstem flows in the lower river through storage and release operations at upstream reservoirs may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has reduced the delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The combined effect of these changes is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs and thus the conservation value of critical habitat for SR fall Chinook salmon within the action area are discussed in more detail in the Environmental Baseline section, below.

2.5.1.3 Climate Change Implications for SR Fall Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of SR fall Chinook salmon and aquatic habitat is climate change. The USGCRP[169] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to

[169] http://www.globalchange.gov

9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[170] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.

Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, earlier emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003, Crozier et al. 2008a, Martins et al. 2012, Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy among interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- Direct effects of increased water temperatures on fish physiology.

[170] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

- Temperature-induced changes to stream-flow patterns, which can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.
- Alterations to freshwater, estuarine, and marine food webs, which alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity, which have changed the abundance and productivity of fish resources.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Crozier et al. (2019) assessed SR fall Chinook salmon as having high vulnerability to the effects of climate change, based on high exposure to climate effects, high biological sensitivity, and high adaptive capacity.[171] For SR fall Chinook salmon, the upstream migration and pre-spawn holding period extends from mid-August through October (Connor et al. 2018). Returning adults are exposed to temperatures exceeding 68°F, with cumulative exposures highest for early-returning adults (Keefer and Caudill 2015). Exposure to stream temperature in the Snake River basin was ranked high for this ESU, and models suggest that future migrants may experience lower migration and spawning success due to rising temperatures (Connor et al. 2018). Nonetheless, the vulnerability of this ESU during the adult freshwater stage was ranked as moderate, because most adults migrate after temperatures have peaked and spawn after temperatures have declined in the fall.

NMFS' life-cycle modeling, which considered three potential levels of changing climate severity over the next 24 years, clearly indicates that climate change effects, especially those that may manifest in the ocean, pose a substantial threat as they can have severe, negative consequences to the overall productivity (and abundance) of all SR spring/summer Chinook salmon populations (see Section 2.5.3.1.10, Life-Cycle Modeling). While ocean-type Chinook salmon are affected by different factors in the ocean than stream-type Chinook salmon, based on the modeling, we expect abundances over the next 24 years to decrease and extinction risk to increase. However, ocean-type Chinook salmon generally appear to be less affected by warming conditions than stream-type Chinook salmon, so we believe the potential effects would be less severe than indicated by the modeling for Snake River spring/summer Chinook salmon.

[171] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results

Egg development is constrained by cold winter temperatures (Connor et al. 2003b), so rising stream temperature during incubation is less of a concern for this ESU. This was reflected in the low sensitivity score for early life history. Juvenile emergence, growth, and migration occur earlier in warmer than in cooler spawning and rearing areas, and certain areas not used as spawning habitat appear to be too cold (Connor and Burge 2003, Connor et al. 2003a, 2003b). Juveniles were observed to tolerate constant temperatures of 71.6°F (22°C) and fluctuating temperatures up to 80.6°F (27°C) (Geist et al. 2010), and they grew well even at reduced rations (Geist et al. 2011). Rapid growth and thermoregulatory behavior (Tiffan et al. 2009) during the predominantly subyearling migration of this ESU allow fish to avoid thermal stress, despite generally warm summer temperatures in the lower Snake River (Connor and Burge 2003). Juveniles rearing in cooler reaches of the Clearwater River have shown a yearling life history, and hence adaptability to a wide temperature range. Thus sensitivity at the juvenile freshwater stage was ranked low.

SR fall Chinook salmon exhibit a wide distribution across the eastern Pacific Ocean, ranging from coastal British Columbia to California and Oregon. A moderate relationship has been reported between survival of subyearlings and the Pacific Decadal Oscillation, and between the northern copepod anomaly index and survival of Columbia River fall Chinook salmon (Peterson et al. 2014). These findings were reflected in a moderate score for marine stage.

SR fall Chinook salmon production is dominated by hatcheries, and the ESU received a very high score for hatchery influence on climate resilience. Extrinsic factors downstream in the Snake and Columbia Rivers range from an increasing proliferation of nonnative species (Sanderson et al. 2009) to a growing list of contaminants (Yeakley et al. 2014). Dams on the mainstem Snake and Columbia Rivers present challenges for both juvenile and adult migration (Smith et al. 2003, Keefer and Caudill 2015). These factors were reflected in a high sensitivity score for other stressors.

Despite the considerable influence of hatcheries on this ESU, there is extensive opportunity for habitat shift and flexibility in age at juvenile migration, resulting in an overall high adaptive capacity.

2.5.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce fitness of salmonids, including SR fall Chinook salmon (Beechie et al. 2013, Wainwright and Weitkamp 2013, Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a, Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Sykes et al. 2009, Whitney et al. 2016).

2.5.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location (Crozier et al. 2008b, Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b, Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely that this increasingly variable flow is detrimental to multiple salmon and steelhead populations in the Columbia River basin.

The effects of climate change on stream ecosystems are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes are likely to lead to shifts in the distributions of native species and facilitate establishment of exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016, Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.5.1.3.3 Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013, Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010, Wainwright and Weitkamp 2013, Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006, Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict inward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species and life history types are highly reliant on estuarine wetlands for rearing, extended estuarine use is important in some populations (Jones et al. 2014). Others, such as SR fall Chinook salmon, benefit from the influx of prey to the mainstem migration corridor (Johnson et al. 2018, PNNL and NMFS 2018, 2020).

2.5.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010, Asch 2015, Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years. For example, range extensions were documented in many species from southern California to Alaska during unusually warm water associated with the marine heatwave known as “the blob” in 2014 and 2015 (Bond et al. 2015, Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002, Fisher et al. 2015). The frequency of extreme conditions such as those associated with marine heatwaves or El Niño events is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015, Rehage and Blanchard 2016). While it is certain that these effects will occur, current models cannot predict the composition or outcomes of future trophic interactions. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm ocean conditions, suggesting that, at a minimum, prey availability and prey quality, “bottom-up” drivers of growth and survival, may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009, Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014, Peterson et al. 2014). Current projections for changes to upwelling are mixed; some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean (Tomaro et al. 2012), and a shift toward food webs with a strong subtropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007, Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in Alaska salmon productivity and survival (Mantua et al. 1997, Martins et al. 2012). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009, Martins et al. 2012). However, more recent information indicates that Alaska salmon, which have historically contrasted with southern populations by benefitting from warm phases of the PDO, no longer have a positive correlation with winter sea-surface temperature (Litzow et al. 2018) and are more synchronized with southern populations (Ohlberger et al. 2016). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells, and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015, Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.5.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change in general, including in the Pacific Northwest. The indirect effects of climate change are also uncertain, including whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013, Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will involve impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning that some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is less certain, leading to a range of potential future outcomes.

2.5.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For SR fall Chinook salmon, we focus our description of the environmental baseline on areas where juveniles and adults are most exposed to the effects of the proposed action. We also consider the broader action area, including tributary and mainstem spawning and rearing areas, because these areas are important context for understanding the effects of the proposed action. The area in which fall Chinook salmon are exposed to the effects of the proposed action includes all waters within the lower Columbia River from the mouth and plume[172] upstream through the lower Snake River to the head of Lower Granite Reservoir on the Snake River and upstream in the Clearwater River to and including the North Fork Clearwater River where SR fall Chinook salmon are present. This includes all waters impounded by Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams and tributary confluences in this reach to the extent they have been inundated by mainstem reservoirs or are affected by flow management.

2.5.2.1. Mainstem Habitat

Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the

[172] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

introduction of nonnative species (e.g., smallmouth bass, walleye, channel catfish, invertebrates, etc.), and other human activities that have degraded water quality and habitat.

2.5.2.1.1 Seasonal Flows

On the mainstem of the Snake[173] and Columbia Rivers, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.5-3). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

[173] The effects of the operation and maintenance of 10 Reclamation projects and two related actions in the upper Snake River above Brownlee Reservoir, including the 2004 Nez Perce Water Rights Settlement and the Snake River Water Rights Act of 2004 (for a 30-year period through 2034; USBR 2007), underwent consultation in 2008 (NMFS 2008a, b).

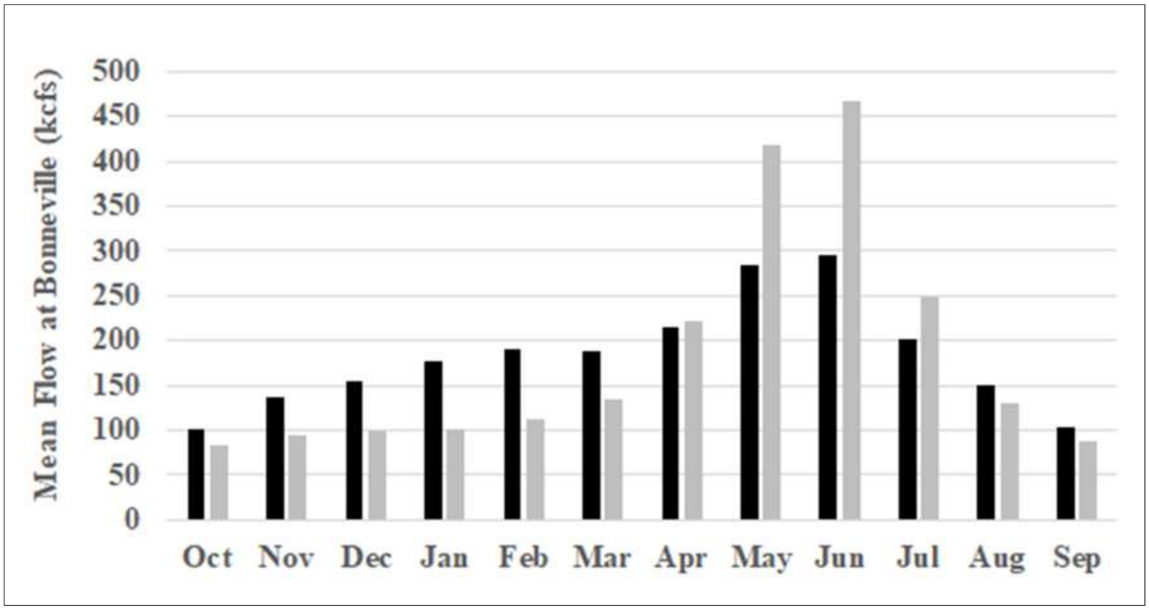

Figure 2.5-3. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[174] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs, including SR fall Chinook salmon, remain nearly constant over a wide range of flows but decline markedly as flows drop below some threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year (Table 2.5-3). This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released

[174] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile SR fall Chinook salmon and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

Table 2.5-3. Seasonal flow objectives and planning dates for the mainstem Columbia and Lower Snake Rivers. NA indicates that there is not a flow objective for the season at these projects.

Location	Spring		Summer	
	Dates	**Objective (kcfs)**	**Dates**	**Objective (kcfs)**
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100[a]	6/21 to 8/31	50 to 55[a]
Columbia River at McNary Dam	4/10 to 6/30	220 to 260[a]	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 to 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160[b]	NA	NA

[a] Objective varies based on actual and forecasted water conditions.

[b] Objective varies according to water volume forecasts and is for chum salmon (spawning period is approximately November 1 through December and protection flow objectives are based on redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

Seasonal flow objectives for improving the migration and survival of spring and summer juvenile migrants are based on water supply forecasts; however, mean seasonal flows in the past did not always achieve the flow objectives when measured as a seasonal average flow. From 1998 to 2019, seasonal spring flow objectives were met or exceeded during 81 percent of years at McNary Dam and during 48 percent of years at Lower Granite Dam. For the years when the spring flow objectives were not met, the average seasonal flow was 88 percent of the spring flow objective at McNary Dam and 78 percent of the spring flow objective at Lower Granite Dam. Across all years, the average percentage of the spring flow objective obtained was 113 percent at McNary Dam and 101 percent at Lower Granite Dam. Achieving these seasonal flow objectives provides multiple benefits for smolts in the migration corridor, estuary, and plume. Higher spring flow helps reduce fish travel time, increases juvenile access to shallow water habitat along the river banks, increases the flux of invertebrate prey to shoreline habitat, increases turbidity (which can reduce predation on juvenile migrants), and increases the size of the Columbia River plume, which is a key transition corridor for smolts to the nearshore ocean environment. Conversely, when seasonal flow objectives are not met, juvenile survival may be reduced via these same pathways of ecological effects.

From 1998 to 2019, summer flow objectives were met or exceeded during 14 percent of years at McNary Dam and during 18 percent of years at Lower Granite Dam. For the years when the summer flow objectives were not met, the average seasonal flow was 74 percent of the summer flow objective at McNary Dam and 66 percent of the summer flow objective at Lower Granite

Dam. Across all years, the average percentage of the summer flow objective obtained was 85 percent at McNary Dam and 79 percent at Lower Granite Dam. The benefits provided by attaining summer flow objectives, and potential impacts associated with not meeting them, are the same as those previously described for the spring flow objectives.

Recommendations on when to manage flows for the benefit of juvenile passage are made by the TMT during the juvenile migration season. These recommendations are informed by the status of the juvenile migration, water supply forecasts, river flow conditions, and river flow forecasts during the juvenile migration season.

2.5.2.1.2 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult SR fall Chinook salmon is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of SR fall Chinook salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Snake and Columbia Rivers on salmon and steelhead survival is a concern; because of temperature standard exceedances, both rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges such as cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

Since the mid-1990s, the Corps has released up to 1.2 million acre-feet of cool water from Dworshak Dam annually on the North Fork Clearwater River to reduce temperatures and enhance flows in the lower Snake River from June or July to September. Operators manage releases from Dworshak Dam so that water temperature at the tailrace of Lower Granite Dam does not exceed 68°F (20°C). This action reduces temperatures in the lower Clearwater River, and the Snake River from the confluence with the Clearwater River to at least Lower Monumental Dam, but has little to no discernible effect on temperature in the Columbia River downstream of the Snake River confluence. Even with the flow augmentation from Dworshak Dam for cooling, temperature criterion exceedances occur frequently at Little Goose, Lower Monumental, and Ice Harbor Dams from mid-July to mid-September (EPA 2020).

The releases from Dworshak Dam cool the lower Clearwater River and Lower Granite Reservoir substantially, although the cooler water is denser and sinks to the bottom, causing vertical stratification of the reservoir. As this water flows downstream, warmer surface water mixes with the cooler, deeper water as it passes through turbines and spillbays at Lower Granite Dam and each subsequent Snake River dam until the cooling effect becomes attenuated below the tailrace of Ice Harbor Dam (NMFS 2008a, 2017a). Figure 2.5-4 depicts this downstream attenuation during the high temperature conditions in 2015. Temperatures were warmest at the Anatone Gage on the Snake River upstream of Lower Granite Reservoir before it was influenced by cooler water from Dworshak Dam. Temperatures were coolest at the Peck Gage on the Clearwater River below Dworshak Dam, and tailrace temperatures proceeding downstream at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams increased at each project. Thus, even in an unusually warm, low-flow year, the cool-water releases from Dworshak Dam substantially improved the summer migration conditions for adult summer Chinook salmon in the lower Snake River compared to the high temperatures that would have been present at these projects without flow augmentation for temperature control. The difference in temperatures after mid-June observed at the Anatone Gage without the cooling effect from Dworshak Dam releases (approximately 22°C to 24°C) compared to that at Lower Granite Dam with the coldwater releases from Dworshak Dam (approximately 18°C to 21°C) is biologically significant; the Oregon and Washington temperature standards for migrating adult salmon both are 20°C (daily maximum or 7-day average daily maximum; EPA 2020), above which survival and reproductive success are expected to decline.

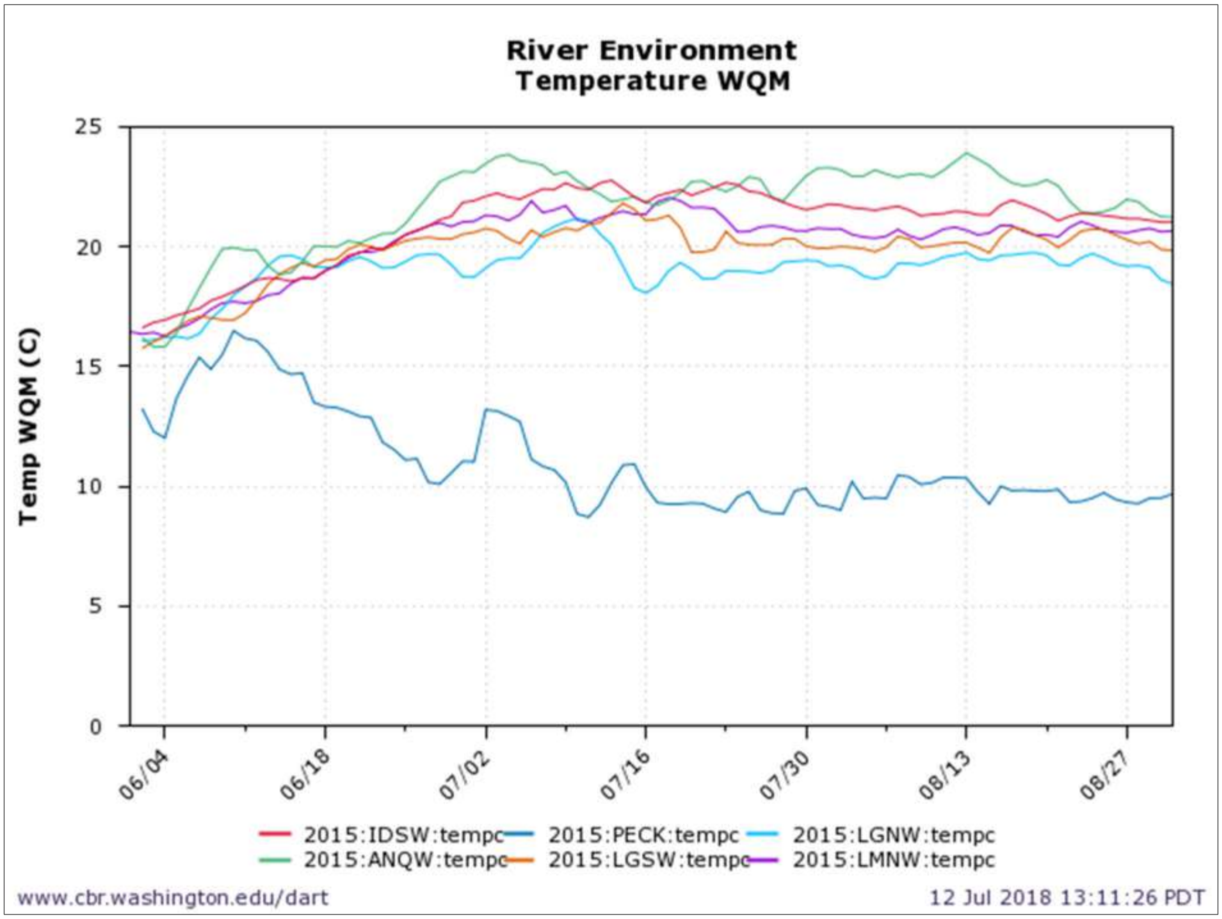

Figure 2.5-4. Water temperature at the Anatone Gage on the Snake River upstream of the Clearwater River confluence (ANQW, green); the Peck Gage on the lower Clearwater River (PECK, dark blue); and, in order from upstream to downstream located below the Clearwater River confluence, the tailrace temperatures at Lower Granite (LGNW, light blue), Little Goose (LGSW, orange), Lower Monumental (LMNW, purple), and Ice Harbor (IDSW, red) dams during summer, 2015.

The Corps also operates fishway exit cooling pumps at Lower Granite and Little Goose Dams to minimize adult passage delays associated with localized temperature differentials between these adult ladders and project forebays, which can potentially improve adult survival rates.

Exposure to elevated summer temperatures in the Columbia River, from its mouth to its confluence with the Snake River, is greatest for the earliest migrating adult Chinook salmon and late summer migrating subyearling Chinook smolts. In the past decade, the migration timing of juvenile SR fall Chinook salmon has shifted earlier in the year, closer to the historical migration timing that SR fall Chinook exhibited before construction of the Lower Snake River dams (NMFS 2017h). Earlier migration timing reduces overall exposure to elevated temperature and warm-water predators and improves overall passage conditions and survival of migrating smolts.

PIT-tag data (DARTe, accessed June 16, 2020) indicate that the middle 90 percent of SR fall Chinook salmon adults historically pass Bonneville Dam from mid-August to the end of

September. Warmer August and September mainstem temperatures could therefore negatively affect adult SR fall Chinook salmon that migrate during this period.

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the middle and lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995a). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam except The Dalles Dam. Biological monitoring (smolts sampled from the juvenile bypass systems at many mainstem dams) shows that the incidence of observed GBT symptoms in both migrating smolts and adults remains between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces.[175] When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure

[175] Monitoring at the Lower Granite Dam trap in 2018 (experiencing higher court-ordered spill operations) and in 2019, showed that GBT and headburn symptoms on adult steelhead and Chinook salmon were similar in prevalence relative to past years (Corps' Lower Granite Adult Trap database accessed on December 10, 2019, and Ogden 2018b). Headburn refers to lesions and ulcers on the heads and jaws of migrating adults that can result from contact with concrete and other structures at dams, and which can increase prespawn mortality (Neitzel et al. 2004).

compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[176] Under recent operations (2008 to 2019), exposure to elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June, affecting most SR fall Chinook juveniles. Defining the relationship between juvenile survival and TDG is difficult in part due to autocorrelation of TDG with other environmental variables. Monitoring data from 1998 to 2018 do not clearly indicate that survival rates have been reduced by increased exposure to TDG.

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

2.5.2.1.3 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of SR fall Chinook salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify.

[176] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[177] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[178] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and, where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic

[177] The Lower Columbia River and Lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[178] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river

activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

Sediment Transport

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

NMFS completed formal consultation for the Channel Maintenance Dredging in the lower Snake and Clearwater Rivers (WCR-2014-1723) on November 14, 2014. This action included dredging material in the Snake and Clearwater Rivers at four sites: 1) the downstream navigation lock approach at Ice Harbor Dam, 2) the Federal navigation channel in the Snake and Clearwater Rivers confluence area, 3) the berthing area for the Port of Clarkston, Washington, and 4) the berthing area for the Port of Lewiston, Idaho. The Corps also issued regulatory permits for dredging at commercial ports and berths operated by local port districts or private companies in Clarkston, Washington, and Lewiston, Idaho. Most of these non-Federal navigation areas consisted of arterial channels leading from the main Federal navigation channel to the port or berth, as well as the areas at the port or berth used for loading, unloading, mooring, or turning around. During in-water work, short-term adverse effects on aquatic resources included elevated turbidity, suspension of chemicals, harassment and entrainment of fish, and disruption of benthic organisms that serve as prey for juvenile salmon. The dredged material was disposed of inriver as fill to construct a shallow-water bench for juvenile fish habitat at Knoxway Bench (RM 116) immediately upstream of Knoxway Canyon.

In 2005 to 2006, the Corps deposited approximately 420,000 cubic yards of sand and silt at the upstream end of the Knoxway Bench site. The Corps then shaped the dredged material to create an estimated 3.7-acre shallow-water habitat bench that could be used by juvenile salmonids, particularly juvenile SR fall Chinook salmon. Post-project monitoring for the 2006 effort by the Corps confirmed that juvenile salmonids have been and are using the site for resting and rearing. With the dredging conducted under the 2014 biological opinion, the materials were deposited downstream from the bench created in 2006, and extended riverward of the existing shoreline. The new material formed a uniform, gently sloping shallow-water bench along roughly 2,500 linear feet of shoreline. This feature added approximately 11.4 acres of shallow-water habitat with features preferred for foraging by juvenile salmonids, particularly fall Chinook salmon. In sum, the dredging activities had some negative effects, but should benefit SR fall Chinook by increasing the amount of available rearing habitat.

2.5.2.1.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adults that are migrating past the dams or within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Most juvenile SR fall Chinook salmon have not been affected by these activities, because they predominantly migrate from May through November, but some juveniles do rear or overwinter in the Snake River and have been impacted by scheduled maintenance activities.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult Snake River fall Chinook salmon has likely resulted in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes have minimized the impacts.

2.5.2.1.5 Adult Migration/Survival

Adult SR fall Chinook salmon migrate from the ocean, upstream through the estuary, and pass eight mainstem dams and reservoirs to reach spawning areas upstream of Lower Granite Dam.

Factors that affect the survival rates of migrating adults include fish condition, harvest, adult dam passage, straying, predation, and temperature and flow conditions that increase the energetic demands of migrating fish (NMFS 2008b).

PIT-tag detectors placed near the exits of ladders at the mainstem dams provide a unique ability to monitor the survival of adult migrants that were tagged as juveniles. Starting with the number of adults detected at Bonneville Dam, minimum estimates of survival to detectors at upstream dams can be derived. Termed "conversion rates," these survival estimates can be adjusted for reported harvest and the expected rate of straying in an unmanaged system. Figure 2.5-5 depicts estimated conversion rates for SR fall Chinook salmon from Bonneville to Lower Granite Dams (seven reservoirs and seven dams) during 2009 to 2019, years that include recent hydropower operations and harvest rates within the Bonneville to McNary "zone 6 fisheries" as designated in the *U.S. v. Oregon* Management Agreement) and in the lower Snake River. The 10-year average survival rate is 89.9 percent (range of 80.2 to 100.9 percent) from Bonneville to Lower Granite Dams.[179] This number includes the losses associated with the hydropower system, as well as any losses in this reach that result from elevated temperatures or from injuries from pinniped attacks downstream of Bonneville Dam. Expressed on a "per project" basis, about 98.5 percent (range of 100.0 to 96.9 percent) of adult SR fall Chinook salmon survived passage through each project (dam and its reservoir).

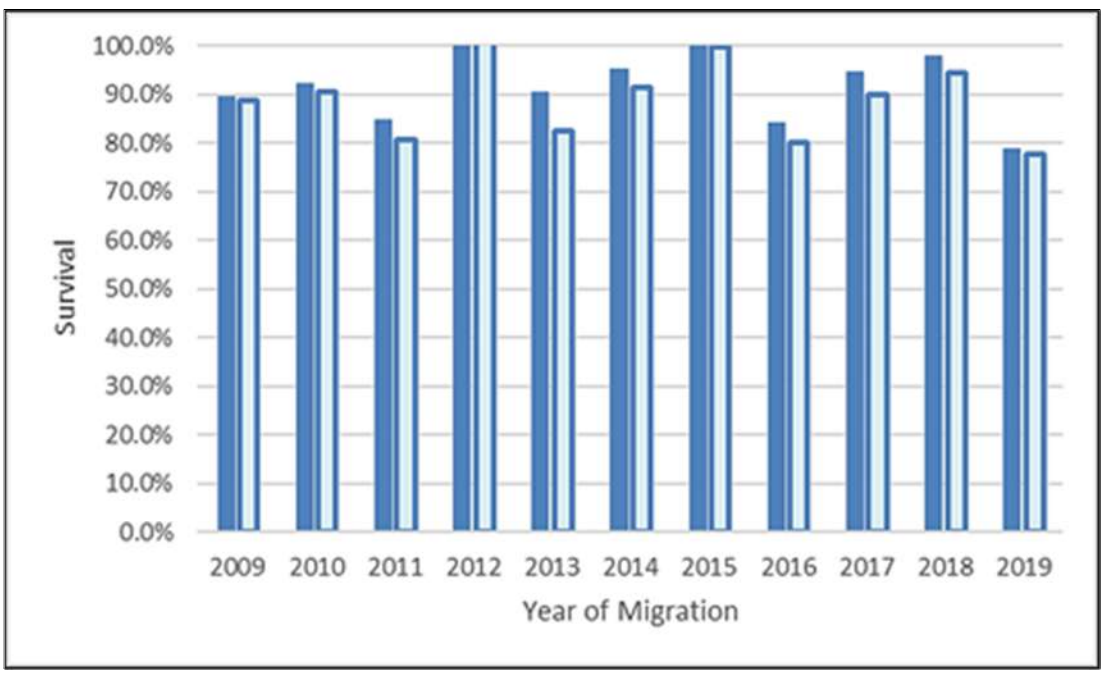

Figure 2.5-5. Conversion rate estimates for known-origin PIT-tagged adult SR fall Chinook salmon (natural- and hatchery-origin combined) from Bonneville to Lower Granite Dams, 2009 to 2019. Source: NMFS, using data from PITAGIS, as described in NMFS (2008b).

179 Conversion rates close to, or higher than, 100 percent (2012 and 2015) are possible if estimates of harvest rates (or natural rates of straying) are higher than what actually occurred in a given year (biased high). Conversely, if harvest rates are underestimated, the resulting conversion rate estimates would be biased low.

Most adult SR fall Chinook migrate in September, when solar heating of surface water in reservoirs can lead to high temperatures at fish ladder exits and temperature differentials between the bottom and top sections in a fish ladder. Ladder temperatures exceeding 68°F and differentials greater than 1.8°F have been demonstrated to delay passage for Chinook salmon and steelhead at the CRS dams in the Lower Snake River (Caudill et al. 2013). As temperature differentials increase, time required for passage increases; a temperature differential of 5.4°F increased the ladder passage time for fall Chinook at Lower Granite Dam by a factor of 4.3 to 5.3 compared to no temperature differential. Caudill et al. 2013 noted that the increased travel time, increased thermal exposure, and related physiological stresses could reduce successful migration to natal tributaries. Ladder temperatures commonly exceed 68°F, and ladder differentials regularly exceed 1.8°F while adult fall Chinook are migrating; during the most extreme summer days, ladder temperatures in CRS dams can exceed 75.0°F, and ladder differentials can exceed 4.5°F (FPC 2019). Fish ladder–cooling structures have been installed at Little Goose and Lower Granite Dams that pump colder water from deeper in the reservoir into the fish ladder to reduce ladder temperature differentials. There are currently no structures to reduce ladder temperatures at the other CRS dams, but research has identified that during the warmest months, cooler water is available that could be pumped into ladder exits to reduce high temperatures and ladder differentials (Lundell 2019).

2.5.2.1.6 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and non-native species that are predators, competitors, or food sources for migrating juvenile Chinook salmon. Travel times of migrating smolts increase as they pass through the reservoirs (compared to a free-flowing river), increasing exposure to both native and nonnative predators (see predation section below), and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spillbays, or surface passage routes) (NMFS 2008a).

Table 2.5-4 depicts the Fish Operations Plan (FOP) for spring spill during 2017 through 2020. There was a substantial increase in spill over the dam spillways in the spring during 2018 in response to a court order requiring additional spill and in 2019 and 2020 under the Flexible Spill Agreement. Spring spill, as a percentage of flow at Snake River dams, averaged 37.2 percent in 2018, with daily mean spill percentages above the long-term spill average (1993 to 2018) for nearly the entire migration period. In the spring of 2019, during the 120 percent flexible spring spill operation, mean discharge in the Snake River was high at 45.5 kcfs, which was above the 2006 to 2019 mean of 34.3 kcfs. In 2019, spill averaged 38.5 percent at the Snake River dams, which was above the long-term mean of 34.6 percent, but lower than what would be expected with flexible spill during low and moderate flow years.

Table 2.5-4. Summary of 2017, 2018, 2019, and 2020 Fish Operations Plan spring spill levels at lower Snake River and Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flexible Spill	2020 Flexible Spill
Lower Granite	20 kcfs/20 kcfs	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 20 kcfs Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 20 kcfs Performance Standard (8 hours per day)
Little Goose	30%/30%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)
Lower Monumental	Gas Cap/Gas Cap (approximate Gas Cap range: 20–29 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (uniform spill pattern, 16 hours per day) / 30 kcfs Performance Standard (bulk spill pattern, 8 hours per day)	125% TDG gas cap (uniform spill pattern, 16 hours per day) / 30 kcfs Performance Standard (bulk spill pattern, 8 hours per day)
Ice Harbor	April 3-April 28: 45 kcfs/Gas Cap April 28-June 20: 30%/30% vs. 45 kcfs/Gas Cap (approximate Gas Cap range: 75–95 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 30% Performance Standard (8 hours per day
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)
John Day	April 10–April 28: 30%/30% April 28–June 15: 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flexible Spill	2020 Flexible Spill
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 40% Performance Standard (8 hours per day)	40%/40%
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)	120% TDG gas cap (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)	125% TDG gas cap up to 150 kcfs (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)

[1] Spill operations are described as percent of project outflow or kcfs.

Overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1991, when the species was listed. This is most likely a result of: 1) a recent shift of subyearling fall Chinook salmon smolts to an earlier migration pattern that more closely approximates the historical migration timing (Mains and Smith 1964, Connor et al. 2013, NMFS 2017h), 2) improved structures and operations, and 3) continuation of predator management programs at the eight mainstem dams and within the reservoirs. The average survival of hatchery-origin subyearling fall Chinook salmon migrating from Lower Granite to McNary Dams improved from 53.2 percent during 1992 to 2005 to 70.2 percent during 2008 to 2017, after the Action Agencies instituted 24-hour spill operations, constructed surface passage routes, and improved juvenile bypass systems at Little Goose, Lower Monumental, and McNary Dams (Figure 2.5-6). Active tagging data indicate improvements made to John Day, The Dalles, and Bonneville Dams likely improved passage conditions and juvenile survival to a similar extent (Fredricks 2017). In the past, too few fish were detected in lower reaches to make survival estimates from Lower Granite to Bonneville Dam, however, Smith (2020) provided new estimates of survival for hatchery-origin subyearlings from Lower Granite Dam to Bonneville Dam. These estimates averaged 50.0 percent for the past ten years (2010 to 2019), and 65.0 percent during recent years (2018 to 2019) that had higher spill operations.

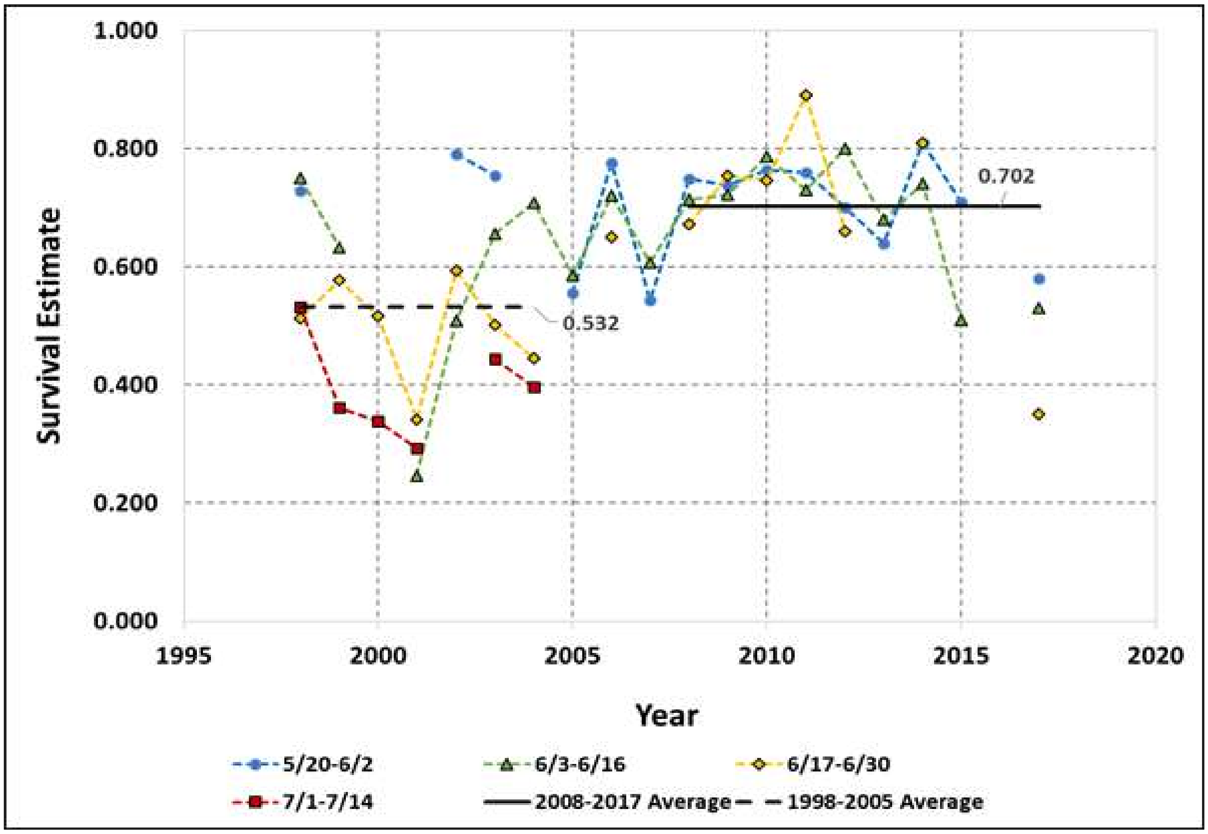

Figure 2.5-6. Survival estimates for hatchery SR fall Chinook salmon from Lower Granite to McNary Dams (1998 to 2017). Source: Fish Passage Center.

In contrast, juveniles from the cooler lower Clearwater River spawning and rearing area often do not migrate as subyearlings, but overwinter in lower Snake River reservoirs before resuming their active migration as yearlings the following spring. While we are unable to estimate the percent of each cohort that uses this life history strategy, the SARs back to Lower Granite Dam of yearling fall Chinook salmon migrants are relatively high, and substantial numbers of returning adults have been linked to this life history strategy (NMFS 2017h). Thus, this life history strategy appears to be relatively stable, productive, and is contributing to the overall abundance and productivity of the lower Clearwater River major spawning area and therefore to the spatial structure and diversity of the population.

2.5.2.1.7 Transportation

Juvenile fish transport has been used for mitigation in the CRS since 1981 (Baxter et al. 1996). The goal of transportation is to avoid mortality directly caused by migration past dams and thus to increase the number of fish that return as adults. Turbine intake screens, part of the juvenile bypass systems,[180] divert smolts away from turbine units and into a system of channels and flumes before bypassing them into the tailrace below the dam or collecting them in raceways

[180] Almost all powerhouses at the eight mainstem dams have juvenile bypass systems. The exceptions are The Dalles Dam and Powerhouse 1 at Bonneville Dam.

where they can be loaded onto barges or trucks, transported below Bonneville Dam, and then released into the lower Columbia River to continue migrating to the ocean. Dams currently used for collection are Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam. SR fall Chinook smolts were transported from McNary from 1985 to 2012, after which all transport from McNary Dam ceased based on a recommendation from NMFS.

The proportion of SR fall Chinook smolts transported has shifted over time. Before 2005, summer spill was not provided at the three Snake River collector projects in order to maximize the proportion of subyearling Chinook salmon collected and transported. Since 2005, spill has been provided to promote juvenile fish passage at each of the mainstem dams (including the collector projects) for 24 hours each day during the spring and summer periods, which has decreased the proportion of fish collected. From 2010 to 2018, an average of 45 percent (range 30 to 61 percent) of natural-origin and 43 percent (range 30 to 56 percent) of hatchery-origin subyearling fall Chinook smolts were transported (DeHart 2018).

Improved structures and summer spill operations improved inriver passage conditions and juvenile survival, as expected, but it was not clear if these improvements would offset the increased direct survival of transported fish. Smith et al. (2018) reported the results of a study designed to specifically assess the response of (hatchery-origin) SR fall Chinook salmon to two alternate management strategies: transport with spill (TWS) versus bypass with spill (BWS). Two types of hatchery-reared fall Chinook salmon were used: 1) standard “production” subyearling fish, and 2) “surrogate” subyearlings produced in a hatchery program designed to better represent naturally reared subyearling Chinook salmon. Juvenile fish were reared, PIT-tagged, and then released upstream of Lower Granite Dam during 6 outmigration years (2006, 2008 to 2012). Detections of adults from these release groups back to Lower Granite Dam were used to estimate SARs.

The design of the fall Chinook salmon transportation study provided a metric that has not been estimated for other species: the “TWS:BWS” ratio. In each year, roughly half of the tagged fish released upstream of Lower Granite Dam were collected and transported if they entered the juvenile bypass system at a collector dam, and half were bypassed. Therefore, within each study group there were fish that never entered a juvenile bypass system, and thus did not receive the treatment. In this way, the return rate for the entire group provided an estimate applicable to the entire population under the overall management strategy, TWS or BWS, not just for those fish actually transported or bypassed.

For the surrogate subyearling Chinook salmon group, transported fish had higher return rates than bypassed fish. The average survival advantage was about 8.5 percent for fish released in the Snake River and 14.9 percent for those from the Clearwater River. For production subyearlings, transported fish had lower return rates than bypassed fish. The average survival disadvantage was about 6.3 percent for fish released in the Snake River and 3.5 percent for those released in the Clearwater River.

These results corresponded with patterns in migration timing: production fish from the Snake River were the first fish to arrive at collector dams, then production fish from the Clearwater River, then surrogates from the Snake River, and finally, surrogates from the Clearwater River. Thus, later-migrating fish had higher return rates under the transport with spill management strategy and earlier-migrating fish had higher return rates under the bypass with spill strategy.

While the primary objective of the fall Chinook transportation study was to assess overall management strategies using the TWS:BWS ratio, other metrics were also derived from the data. Most notably, Smith et al. (2018) estimated T:B for each collector dam in each study year. The geometric means of annual T:B ratio estimates for surrogates were 1.24 for Lower Granite Dam, 1.30 for Little Goose Dam, 1.23 for Lower Monumental Dam, and 2.17 for McNary Dam. For production subyearlings, the respective geometric means were 0.76 for Lower Granite Dam, 0.88 for Little Goose Dam, 0.94 for Lower Monumental Dam, and 2.38 for McNary Dam. These data indicated the "surrogate" population (later migrating juveniles) benefited from transportation, while the "production" population (earlier migrating juveniles) did not.

Finally, Smith et al. (2018) used information on the timing of passage through juvenile bypass systems to look more closely at trends within season. For both production and surrogate subyearlings, they found that the earliest arriving fish tended to have higher return rates if bypassed, while later-migrating fish had higher return rates if transported. For surrogate fish, SARs of transported fish tended to exceed those of bypassed fish starting in the first or second week of July and continued to increase through August, peaking around September 1. For production fish, the SARs of transported fish tended to exceed the SARs of bypassed fish by the third week of June in most years, though only a small proportion of production fish passed that late in the season. The authors recommended that the management strategy to maximize SARs for SR fall Chinook salmon in isolation (i.e., not considering potential effects on other Snake River ESUs/DPSs that migrate at the same time) would be to bypass juveniles early in the season and transport them later in the season; they recommended July 1 as the best day to start transportation, weighting impacts to subyearling surrogate and production fish equally.

While the overall result of transportation is positive, smolt transportation is not a panacea (Williams et al. 2005). Informally, a regional goal is for survival of inriver migrants to meet or exceed that observed for transported fish. That goal has not yet been met for spring migrants, but survival rates for transported fish provide an important benchmark. The alternative to transportation is to improve inriver migration conditions to the point where transportation provides little benefit. Over the last several decades various transportation strategies have been proposed and have been reviewed by the ISAB, most recently in 2010 (ISAB 2010). The guidance provided by the ISAB has been consistent, which is to "spread the risk" between transport and inriver passage, and to measure the effects of inriver survival and transportation over time. The T:B and TIR ratios provide the information necessary to measure these effects.

Since 2006, efforts to improve conditions for smolts migrating inriver have included the provision of 24-hour spill during juvenile migration at all of the mainstem projects, the addition of surface passage structures, and the relocation of juvenile bypass outfall locations to improve inriver survival of bypassed fish. The most recent change was the implementation of the Flexible Spill Agreement, which as of spring 2020 had increased spring spill levels up to a 125 percent TDG tailrace standard (16 hours per day) at the Snake River projects and McNary Dam (NMFS 2019a).

While higher spill is anticipated to result in fewer smolts at a project being bypassed and collected for transport, that effect would not be uniform under all flow conditions. At a given spill level, more fish will pass via spill under low-flow conditions. When inriver conditions are poor due to low flows and high water temperatures, as occurred in 2015, in-season management decisions must weigh the potentially large benefits of increasing the proportion of fish transported against the general desire to improve inriver conditions, with spill as the main strategy identified to date.

In general, determining an "optimum" transport operation is challenging for several reasons. The benefit of transportation varies seasonally, by river flow and temperature conditions, by collector dam, and likely also because of differing ocean conditions at the time of ocean entry for transported and inriver migrants. Seasonal patterns in the SARS of transported and inriver migrants also vary by species and rearing type.

In addition, transport has unintended consequences. Handling and transport of juveniles results in their being held at much higher densities than observed in the wild, increasing the risk of disease transmission. Also, because it takes inriver migrating fish several weeks (or months, for those adopting the yearling life history strategy) to travel from the lower Snake River to Bonneville Dam, and they are growing during that period, inriver migrants are larger and enter the Columbia River estuary and plume later in time than transported fish. Smaller size at ocean entry is associated with reduced survival (NMFS 2014a). These factors, in some combination, likely contribute to the sometimes observed higher mortality for transported fish after being released from barges compared to inriver migrating smolts as evidenced by adult returns to Bonneville Dam (NMFS 2008a).

Another unintended consequence of transport is increased straying of returning adults (Keefer and Caudill 2014). Smolts that migrate inriver take 2 weeks or longer to travel from Lower Granite Dam to Bonneville Dam, imprinting on the varying water chemistry of tributaries as they go. Smolts transported in barges follow the course of the river, but they make the trip in 2 to 3 days. It appears that the reduced transit time prevents fish in barges from acquiring waypoints along the migration route as effectively, and this can result in less directed upstream migration for returning adults. It is not known whether transported fish wander between major spawning areas at higher rates than inriver migrating adults upstream of Lower Granite Dam. This is likely to have a small, or negligible, negative effect on the diversity of SR fall Chinook salmon, given that whether they stray or not, all belong to a single large population.

The SARs presented in this document are based on adults counted at Lower Granite Dam. Thus, losses of transported fish resulting from straying are accounted for, and TIR and T:B estimates still show a general benefit of transport. Uncertainty remains about whether alteration of adult-homing behavior has important consequences for fitness after adults successfully pass Lower Granite Dam.

2.5.2.2 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Fall Chinook salmon are produced in four hatchery programs that are part of the SR fall Chinook salmon ESU and funded as mitigation for fish production lost through construction and operation of hydropower dams in the Columbia and Snake River Basins. Releases of hatchery fish from these programs all provide fish for harvest, but some releases are also intended to return hatchery fish to spawn naturally to increase the abundance of the naturally spawning population. In a 2012 biological opinion on the SR fall Chinook salmon hatchery programs, NMFS concluded that the proportion of hatchery-origin fish spawning naturally, coupled with the presumed proportion of natural-origin fish in the broodstocks, led to a proportionate natural influence (PNI) that was considerably lower than the 67 percent recommended for a population of high conservation concern, and that these programs therefore posed a fitness risk through hatchery-influenced selection (NMFS 2012b). While recognizing these risks, we also considered that although, in theory, the presence of so many hatchery-origin fish on the spawning grounds should cause fitness to decline, natural production in the population was increasing. Given that the hatchery program was also increasing in size, it was possible that the increase in natural production was caused by spawning of an increasing number of hatchery-origin fish, but it could not be ruled out that this was a supplementation response. Based on this hypothesis and the relatively short number of generations the population had been subjected to hatchery influence, NMFS concluded that issuing an ESA Section 10 permit to continue operation of the programs through broodstock collection, without attempting to reduce hatchery influence, posed low risk to the survival or recovery of the population and thus the SR fall Chinook salmon ESU (NMFS 2012b).

The recent proposed action from the *U.S. v. Oregon* biological opinion (NMFS 2018a), as well as a new site-specific SR fall Chinook salmon hatchery biological opinion (NMFS 2018b), included the movement of the 1 million fall Chinook salmon that Idaho Power Company released from the Hells Canyon reach into the Salmon River. Based on our current understanding of homing fidelity of SR fall Chinook salmon, the reprogramming of the Idaho Power Company releases should lessen the effects of the hatchery programs in the upper Snake River area (above the Salmon River) (NMFS 2017h). While we anticipate that this change will substantially reduce genetic risk from current levels, considerable uncertainty remains. However, it also potentially offers large benefits in terms of better understanding this salmon population, as well as providing critical information on the consequences of large-scale perturbations in hatchery/natural dynamics. In addition, the population is now being managed at a much higher PNI level than it was previously. Although the hatchery programs continue to pose a risk, the level is considerably reduced from previous levels and at this point do not appear to pose a risk to the survival or recovery of SR fall Chinook salmon (NMFS 2018b).

The SR fall Chinook salmon recovery plan (NMFS 2017h) outlines the following three potential recovery scenarios: 1) Achieve highly viable status for the extant Lower Snake River population and viable status for the currently extirpated Middle Snake River population, 2) Achieve high certainty of highly viable status for Lower Snake River population with the status of the population evaluated in the aggregate, and 3) Achieve high certainty of highly viable status for the Lower Snake River population by evaluating status based on one or more Natural Production Emphasis Areas (NPEA). An NPEA is a region of greatly reduced hatchery influence compared to other spawning areas. Updated homing fidelity information from the *Snake River Fall Chinook Symposium* (USFWS 2017) informed the preliminary feasibility of the NPEA and suggests that it may be possible to create such a scenario under the Idaho Power Company's plan to move hatchery releases from Hells Canyon to the Salmon River. Even though these releases were relocated in an attempt to increase survival rates for that component of the program, an ancillary benefit of the relocation may be the opportunity to develop an NPEA.

Hatchery production levels in the Snake River basin and the interior Columbia River basin are expected to continue at levels similar to those observed in recent years. The effects of these hatchery programs (to the extent they have affected the status of SR fall Chinook salmon through competition, predation, etc.) are expected to continue. Moving the release location of one million hatchery fall Chinook salmon from Hells Canyon Dam to the Salmon River basin is expected to improve the productivity (and potentially the diversity) of naturally produced SR fall Chinook salmon in the upper Hells Canyon reach of the Snake River.

Overall hatchery production levels in the lower Columbia River are expected to decrease following implementation of the terms and conditions in the biological opinion on Mitchell Act-funded hatchery programs (NMFS 2017h). This should decrease the effects of hatcheries (competition and predation effects and, potentially, disease effects) on SR fall Chinook salmon smolts rearing in, or migrating through, the lower Columbia River and estuary.

2.5.2.3 Recent Ocean and Lower River Harvest

The 2018 to 2027 *U.S. v Oregon* Management Agreement, signed by NMFS in February 2018, provides the current framework for managing fisheries and hatchery programs in much of the Columbia River basin. The Management Agreement accomplishes two primary objectives. First, it implements harvest policies that the parties[181] have agreed should govern the amount of harvest. Second, it incorporates hatchery programs that provide harvest opportunities and that are important to the conservation of salmon and steelhead runs above Bonneville Dam. NMFS' decision to sign the Management Agreement took into account the recently completed Final EIS and the associated biological opinion (NMFS 2018a). As a result, fisheries affecting SR fall Chinook salmon in the 2018 to 2027 *U.S. v. Oregon* Management Agreement are aligned with the recovery plan strategies in the recovery plan (NMFS 2017h).

SR fall-run Chinook salmon are caught in ocean fisheries off the coasts of Oregon, Washington, and British Columbia. In fall fisheries, they are caught in the Columbia River mainstem and tributaries. Since 2012, they have been managed subject to an abundance rate schedule for a total exploitation rate that ranges from 30 to 41 percent.[182] Recent exploitation rates have been highly variable, but have averaged 37.2 percent since 2008. Total exploitation rates on natural-origin SR fall Chinook salmon have ranged between about 40 and 50 percent since the early 1990s (NMFS 2019d).

2.5.2.4 Tributary Habitat

SR fall Chinook salmon are primarily mainstem spawners with limited reliance on tributary habitats. Historically, SR fall Chinook salmon spawned in the currently available habitat in the Hells Canyon reaches of the Snake River and the lower segments of the Clearwater, Grande Ronde, and Tucannon Rivers. However, the vast majority of these fish spawned in the lower gradient, historically more productive habitat in the mainstem Snake River above the current Hells Canyon Dam (NMFS 2017h). Today, most (53 percent of redds counted since 1992) spawn in mainstem reaches of the Snake River from below the Hells Canyon Dam Complex to the mouth of the Salmon River (RM 247 to 188). This river reach is not typical of productive fall Chinook spawning and rearing habitat, being relatively fast and narrow, with high, steep canyon walls and stretches of white water. River flow and volume in this reach are dominated by the outflow of the Hells Canyon Dam Complex. The thermal regime in this reach is likely more productive for fall Chinook salmon today than it was historically due to the influence of the Hells Canyon Complex. However, other issues associated with the operation of the Hells Canyon Complex limit SR fall Chinook salmon viability in this reach. These factors include exposure to low dissolved oxygen levels in the late summer and early fall, which could negatively affect adult migrants and gamete viability in the reach immediately downstream of Hells Canyon Dam; elevated TDG levels in winter and spring, which could cause gas bubble disease in juveniles; altered flows (on a seasonal, daily, and hourly basis), which could result in altered migration patterns, juvenile fish stranding, and entrapment; and entrapment of sediment, which could result in reduced turbidity and higher predation. Since 1991, the Idaho Power Company, which

[181] The Nez Perce, Umatilla, Warm Springs, Yakama, and Shoshone-Bannock Tribes; the states of Washington, Idaho, and Oregon; and NMFS, the USFWS, and the Bureau of Indian Affairs are signatories of the Management Agreement.

[182] Exploitation rate is the proportion of the total return of adult salmon in a given year that die as a result of fishing activity.

operates the Hells Canyon Complex, has provided stable flows for spawning fall Chinook salmon from mid-October to early December, minimum flows through the winter and early spring to protect incubating eggs and emerging fry, and measures to reduce entrapment. In addition to these effects, Lower Granite Reservoir has inundated historical spawning and rearing habitat (NMFS 2017h).

Spawning also occurs in the lower mainstem Clearwater River (and lower reaches of tributaries to the Clearwater) and, in smaller numbers, in the lower reaches of the Grande Ronde River (and some of its tributaries) and the lower Tucannon River. Even more limited spawning occurs in the lower Imnaha River and the lower Salmon River (NMFS 2017h).

Spawning in the lower Clearwater River (which currently produces about 27 percent of all SR fall Chinook salmon redds) occurs primarily in the mainstem Clearwater River below the confluence with the North Fork Clearwater, although spawning adults have also been observed in the lower Middle Fork Clearwater and in lower portions of the Potlatch, South Fork Clearwater, and Selway Rivers. Flows and temperatures in the lower Clearwater River are highly influenced by operations at Dworshak Dam, where releases of cool water substantially cool the lower Clearwater River (see Section 2.5.2.1.2). Land uses in some areas of the mainstem Clearwater River and its tributaries may also affect fall Chinook salmon. Potential impairments include loss of side channels due to shoreline hardening, which could reduce the availability of rearing habitat, and excess sediment, excess nutrients, and possible toxic contamination from degraded upstream tributary habitats, which could reduce juvenile survival (NMFS 2017h).

The lower Grande Ronde River currently produces about 5 percent of all SR fall Chinook redds. While more evaluation is needed to understand how habitat conditions in the lower Grande Ronde River affect fall Chinook salmon spawning and rearing, potential factors include lack of habitat quantity and diversity, excess fine sediment, degraded riparian conditions, low summer flows, and water quality impairments. Activities in the lower Grande Ronde River that may have reduced habitat quantity and quality for fall Chinook salmon include past and present land use, such as livestock grazing, road development, timber harvest, and recreation. Upstream activities (water diversions, agriculture, roads, livestock grazing, etc.) may also contribute to limiting factors in the lower Grande Ronde River (NMFS 2017h).

The lower Tucannon River currently supports about 6 percent of all naturally spawning SR fall Chinook salmon, but surveys indicate that nearly all these spawners are of hatchery origin. There is little information available regarding the quality and quantity of habitat available to support SR fall Chinook salmon spawning and rearing in the Tucannon River, and it is not clear whether the lack of natural-origin spawners is due to habitat conditions in the river or to some other factors (NMFS 2017h). The WDFW classified sediment load and habitat quantity as primary limiting factors for fall Chinook salmon in the Tucannon River and habitat diversity and channel stability as secondary limiting factors (WDFW 2004). Land uses in the subbasin that could contribute to these impairments include agriculture, timber harvest, and livestock grazing (NMFS 2017h).

The lower Imnaha and lower Salmon Rivers, both tributaries to the Snake River, contribute small percentages (1.8 percent and 0.8 percent respectively) to total SR fall Chinook salmon redd counts. There is little information available regarding factors that may be limiting SR fall Chinook salmon production in these areas, but potential limiting factors include fine sediment levels in spawning substrate and water temperatures in the lower Imnaha River (although SR fall Chinook salmon may not be affected by these high temperatures because of the timing and short duration of their residence in the river system) (NMFS 2017h).

Numerous tributary habitat protection and restoration efforts have been implemented in recent years through the combined efforts of local recovery planning groups, Federal and state agencies (including the Action Agencies), tribal governments, local governments, conservation groups, private landowners, and other entities. While these efforts have focused primarily on upstream segments of basins used by spawning and rearing spring/summer Chinook salmon and steelhead, some small, incremental benefit (e.g., improved flows, reduced sediment, etc.) from these actions would be expected to translate to the lower river reaches of the Tucannon, Grande Ronde, and Clearwater Rivers (three of the five major spawning areas used by SR fall Chinook salmon) (NMFS 2017h).However, degraded habitat conditions, particularly with regard to channel complexity, floodplain connectivity, water quality, hydrologic patterns, and toxic contamination likely continue to negatively affect SR fall Chinook salmon abundance, productivity, spatial structure, and diversity to some extent. While mainstem Snake River reaches contain most of the current and potential spawning habitat for the extant SR fall Chinook salmon population, some opportunities exist to expand natural production in the tributary spawning areas used by the population (NMFS 2017h).

2.5.2.5 Estuary Habitat

The Columbia River estuary provides important migratory habitat for both yearling and subyearling SR fall Chinook salmon. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for smaller subyearling Chinook salmon and reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles, including subyearling SR fall Chinook salmon, migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review (NMFS 2016b), have improved access and connectivity to floodplain habitat. From 2007 through 2019, the Action Agencies implemented 64 projects including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents more than a 2.5 percent net increase in the connectivity of habitats used extensively by subyearling Chinook salmon (Johnson et al. 2018).

In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Floodplain habitat restoration affects the performance of juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) are also exported into the mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Thus, while large subyearling and yearling SR fall Chinook salmon may not enter a tidal wetland channel (wetland catches are dominated by fry (<60 mm fork length) and fingerlings, rarely larger than 90 mm; Kidd et al. 2019), they still derive benefits from wetland habitats. Improved opportunities for feeding on preferred prey that drift into the mainstem are likely to contribute to survival on ocean entry.

As discussed in Section 2.5.2.1.2 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities, create favorable conditions for invasive, pollution-tolerant plants and animals, and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.5.2.6 Predation

A variety of bird and fish predators consume juvenile SR fall Chinook salmon on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. This section discusses predation rates and describes management measures to reduce the effects of the growth of predator populations within the action area.

2.5.2.6.1 Avian Predation

Avian Predation in the Lower Columbia River Estuary

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds. The SR fall Chinook salmon ESU produces both spring (yearlings that overwintered in lower Snake River reservoirs) and summer (subyearling) outmigrants.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including SR fall Chinook salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001 to 2015, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this ESU were about 2.9 and 2.7 percent, respectively, before efforts to manage the size of these colonies (Evans and Payton 2020). Tern predation rates have decreased to 1.0 percent since 2007, a statistically credible difference (Evans and Payton 2020) (Appendix B). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on SR fall Chinook salmon in 2003 to 2014 was 2.7 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[183] where smolts are likely to constitute a larger proportion of the cormorants' diet. The average annual predation rates on SR fall Chinook salmon reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the post-management period (3.7 percent in 2015 to 2017 and 0.9

[183] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

percent in 2018) therefore cannot be directly compared to that before management began, and are likely to underestimate predation rates in the estuary.

Avian Predation in the Hydrosystem Reach

The following paragraphs describe avian predation in the mainstem lower Snake and Columbia Rivers from Bonneville Dam to the head of Lower Granite Reservoir.

SR fall Chinook survival in the mainstem is affected by avian predators that forage at the mainstem dams and reservoirs. The 2008 biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84 to 94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[184]

Juvenile SR fall Chinook salmon are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Predation rates on this ESU generally have been less than 0.1 percent per colony, much lower than for SR or UCR steelhead. These smolts come within foraging range of other nesting sites on the plateau (principally the Blalock Islands in John Day Reservoir) as they migrate downstream, but predation rates on SR fall Chinook have remained less than 1 percent at this location, as well.

The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been focused on keeping terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015, and similar efforts by Reclamation are in progress at Goose Island. However, the number of terns nesting at the Blalock Islands in John Day Reservoir was 10 times higher in 2015 than the year before, and resightings of colored leg-banded terns indicated that large numbers had moved there from Crescent Island (Collis et al. 2019). Terns have also moved to sites in the interior plateau from East Sand Island in the estuary and from alternative Corps-constructed colony sites in southeastern Oregon and northeastern California

[184] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams" (Zorich et al. 2012).

when those areas experienced severe drought (Roby et al. 2017). Nonetheless, the numbers of pairs of Caspian terns nesting on the Columbia plateau in 2018 represented a 44 percent drop from the pre-management period, and predation rates by terns for SR fall Chinook salmon at sites on the Columbia plateau were below 2 percent in 2015 to 2018 at each of these nesting colonies (Evans and Payton 2020) (Appendix B). This ongoing suite of colony management actions is likely to continue the low levels of predation by terns in the interior Columbia River basin on SR fall Chinook salmon.

Predation by gulls was not considered to warrant management actions at the time the IAPMP was developed, and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on juvenile SR fall Chinook salmon smolts from this ESU averaged 2 percent or less during 2007 to 2019 for gulls nesting on Island 20, Badger, Crescent, Blalock and Miller Rocks (Evans and Payton 2020).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on SR fall Chinook salmon after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. In order to evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts overestimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead, and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different although related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns (an additive effect). But the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, will also be important.[185]

With respect to managing terns in the estuary, Caspian terns nesting on East Sand Island were eating an annual average of 2.9 percent of juvenile outmigrants before management actions reduced the size of that colony and 1.0 percent per year thereafter (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (2.9 percent), the average 1.9 percent per year decrease achieved by reducing the size of the tern colony, and that some level of compensation is likely to have occurred in the ocean even in favorable ocean years, it is likely that this management measure did not lead to increased adult returns for SR fall Chinook salmon. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling have reduced average annual prediction rates from 3.8 percent to less than 1 percent, a small decrease. However, in this case, smolt predation rates are likely to have increased because thousands of birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[186]

2.5.2.6.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia and Snake Rivers followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the Northern Pikeminnow Management Program (NPMP) in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). From 2015 to 2019, an annual average of 43 adult, 18 jack, and 104 juvenile Chinook salmon were incidentally caught in the Sport Reward Fishery (Williams et

[185] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

[186] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were SR fall Chinook salmon.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). They also reported an average of one adult and zero juvenile Chinook salmon killed or handled per year. In addition, they caught, but did not remove, an annual average of 967 smallmouth bass and 379 walleye at the two dam angling sites combined over the last 5 years (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). The Oregon and Washington Departments of Fish and Wildlife, which manage these two non-native predator species, are currently discussing the possibility of removing smallmouth bass and walleye from the system when captured by the Dam Angling Program (as with pikeminnow). Both agencies have already removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these species, in addition to pikeminnow, both in the lower Columbia River and the CRS reservoirs (i.e., hydrosystem reach), would incrementally improve juvenile salmonid survival during their migration to the ocean.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile Chinook salmon, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. Williams et al. (2018) found a lower than average abundance (1990 to 2018) for northern pikeminnow in The Dalles and John Day Reservoirs along with a two to three times higher than average abundance for smallmouth bass and walleye in the same reservoirs. With the exception of the John Day forebay area, smallmouth bass abundance index values calculated for 2018 were the highest observed since 1990. Abundance index values provide a means to characterize relative predation impacts (Williams et al. 2018). Similarly, in 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP, as well as a substantial increase in their predatory impact in the lower Snake reservoirs since program design and implementation. Also compared to previous years, walleye were relatively abundant in both The Dalles and John Day Reservoirs during 2018 spring sampling, but few were encountered during the summer sampling. The greatest walleye abundance indices were observed in the John Day Dam tailrace and mid-reservoir, with the tailrace value being the highest recorded abundance to date (Williams et al. 2018). These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal still remains unclear. The complexity of inter-species interactions, combined with inter-reservoir variability and environmental variability, make this a difficult research question to answer without a more intensive sampling and evaluation program (Williams et al. 2018, Winther et al. 2019). However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the Chinook salmon that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including SR fall Chinook salmon. As such, it likely continues to benefit the ESU.

2.5.2.6.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions *(Zalophus californianus)*, Steller sea lions *(Eumetopias jubatus)*, and harbor seals *(Phoca vitulina)* all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. The ODFW counted the number of individual California sea lions hauling out in the Columbia River mouth at the East Mooring Basin in Astoria, Oregon, from 1997-2017. Pinniped counts at the mooring basin during September and October, when SR fall Chinook salmon adults are migrating, increased from an average of 269 from 2008 to 2014 to an average of 914 in 2015 and 2016 (Wright 2018) (Table 2.5-5). Rub et al. (2018) found strong evidence that the recent increases in Chinook salmon loss estimates were a function of the large increase in pinnipeds in the Columbia River.

Table 2.5-5. Maximum monthly counts of California sea lions at Astoria, Oregon, East Mooring Basin, 2008-2017 (counts ended in June 2017, so N/A means more recent data are not available) (Wright 2018).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	40	56	67	126	162	46	6	191	213	204	273	157
2009	27	42	84	118	173	45	38	346	376	241	89	84
2010	58	93	136	229	216	157	29	316	356	265	98	54
2011	19	42	77	155	242	126	11	302	246	85	159	106
2012	20	27	82	240	201	92	19	212	187	147	91	21
2013	37	149	595	739	722	153	8	368	377	208	182	100
2014	237	586	1420	1295	793	90	32	423	492	369	94	126
2015	260	1564	2340	2056	1234	623	37	394	1318	459	84	208
2016	788	2144	3834	1212	1077	620	3	291	1004	878	235	246
2017	1498	2345	808	1131	1204	573	N/A	N/A	N/A	N/A	N/A	N/A

Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019 respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between river mile 112 and McNary Dam (river mile 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

Within the Columbia River, adult salmonid losses due to pinniped predation are greatest directly downstream of Bonneville Dam (Rub et al. 2018). The dam provides a predation advantage, as fish congregate in search of ladder entrances; this can concentrate fish, making them more vulnerable to predation (Stansell 2004). Biologists have been estimating consumption by pinnipeds directly below Bonneville Dam since 2002 (Tidwell et al. 2020), and they monitored predation in the fall and winter months in 2017 and 2018 in response to increases in Steller sea lion presence in the last decade, especially outside of the traditional spring monitoring period. Between 21 July and 31 December 2017, Tidwell et al. (2018) documented an average of 14.5

Steller sea lions per day at Bonneville Dam and an average of 21.1 Steller sea lions were recorded in 2018 (Tidwell et al. 2020). Based on predation observation during these periods, they estimate that pinnipeds consumed 0.7 percent of the fall Chinook salmon run in 2017 and 0.6 percent in 2018 (Table 2.5-6) (Tidwell et al. 2018, 2020); this serves as a reasonable estimate for the percentage of SR fall Chinook salmon consumed directly below Bonneville Dam. A small number of California sea lions (0-5) have also been observed in Bonneville Reservoir.

Table 2.5-6. Adjusted consumption estimates on adult salmonids (including adults and jacks) and white sturgeon by 299 California and Steller sea lions at Bonneville Dam between 30 August and 31 December 2017.

	Adjusted Salmonid Consumption Estimates	Range of Estimate	Total Salmonid Passage at Washington Shore	% Total Passage Consumed	Salmonid Passage at Washington Shore during Observation Period	% Observed Passage Consumed
Chinook	1,433	1,075–1,797	204,707	0.70%	54,371	2.63%
Coho	1,455	1,119–1,787	49,630	2.93%	11,896	12.23%
Steelhead	475	229–695	26,169	1.82%	7,967	5.96%
Sturgeon	999	739–1,237	NA	NA	NA	NA
All Salmon	3363	340–3,699	280,517	1.19%	74,262	4.53%

2.5.2.7 Research, Monitoring, and Evaluation Activities

The primary effects of the past and present CRS-related RME program on SR fall Chinook salmon are associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RME actions also involve sacrificial sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods that can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were SR fall Chinook salmon. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the SR fall Chinook salmon ESU by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of SR fall Chinook salmon that have been handled (or have died) each year as the average annual take reported for 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately.

- Average annual estimates for handling and mortality of SR fall Chinook salmon associated with the Smolt Monitoring Program and the CSS were as follows:
    - Zero hatchery and zero natural-origin adults were handled.
    - Zero hatchery and zero natural-origin adults died.
    - 48,077 hatchery and 33,372 natural-origin juveniles were handled.
    - 326 hatchery juveniles and 246 natural-origin juveniles died.

- Average annual estimates for SR fall Chinook salmon handling and mortality for all other fish RME programs were as follows:
  - 4,202 hatchery and 3,635 natural-origin adults were handled.
  - One hatchery and one natural-origin adults died.
  - 116,907 hatchery and 21,825 natural-origin juveniles were handled.
  - 35 hatchery and 14 natural-origin juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) of SR fall Chinook salmon associated with these elements of the RME program has, on average, affected 33.3 percent of the natural-origin adult (recent, five-year average) run (arriving at Lower Granite Dam) and 6.8 percent of the naturally produced juveniles (recent, five-year average) (Thompson 2020). Most of the natural-origin adults affected by RME activities in recent years (3,491 out of 3,552 in 2019) were fish being diverted through the Lower Granite Dam adult trap for life-cycle modeling data collection purposes, as well as fish being incidentally diverted during hatchery broodstock collection efforts (as this is the only route through which migrating fish can pass when the trap is in operation). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects SR fall Chinook salmon.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the ESU level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.5.2.8 Critical Habitat

The condition of SR fall Chinook salmon critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized here in Table 2.5-7. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.); reduced water quality; and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for SR fall Chinook salmon production have been weakened. Conditions in the hydrosystem reach were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for SR fall Chinook salmon have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.5-7. Physical and biological features (PBFs) of designated critical habitat for SR fall Chinook salmon**.**

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF in the Action Area
Freshwater spawning and rearing sites	Spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, space	**Lower Clearwater River** Reduced habitat complexity and floodplain connectivity (urban and rural development, forest and agricultural practices, and channel manipulations) have reduced the quality of freshwater spawning and rearing sites. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning and rearing sites. Elevated temperatures during winter spawning and incubation periods (Dworshak Dam operations) have reduced water quality at freshwater spawning sites. Cool-water temperatures during the late-June or early-July to mid-September rearing periods (Dworshak Dam operations) have reduced water quality at freshwater rearing sites. Toxics accumulations (water withdrawals, urban and rural development, and forest and agricultural practices) have reduced water quality at freshwater spawning and rearing sites. **Hells Canyon Reach of the Lower Snake River** Stabilization of flows (operations at Hells Canyon Dam) has improved water quantity and space in spawning and rearing habitat. **Lower Snake River (CRS) Reservoirs** Inundation (hydrosystem development) has limited the quantity of spawning and rearing sites. None or very little of this habitat is available within these reservoirs' operating range. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning and rearing sites. Toxics accumulations (water withdrawals, urban and rural development, and forest and agricultural practices) have reduced water quality at freshwater spawning and rearing sites.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF in the Action Area
		Elevated temperatures during winter spawning and incubation periods (Dworshak Dam operations) has reduced water quality at freshwater spawning sites.
Adult and juvenile migration corridors	Substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food (juvenile migration corridor), riparian vegetation, space, safe passage	*Effects on migration corridor PBFs apply to the single extant population of SR fall Chinook salmon:* Alteration of the seasonal flow regime in the Columbia and lower Snake Rivers with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderate negative effect in lower flow years. Alteration of the seasonal mainstem temperature regime in the Columbia and Snake Rivers due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in late summer and fall (hydrosystem development and operations).[1] This has negatively affected the functioning of water quality in the juvenile and adult migration corridors for the latest migrating subyearling smolts and the earliest migrating adult SR fall Chinook salmon. To prevent migration delays in the lower Snake River, the Action Agencies release cold water from Dworshak Dam on the North Fork Clearwater River so that temperatures in the Lower Granite tailrace do not exceed 68°F and operate fishway cooling pumps at Lower Granite and Little Goose Dams. Reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume (hydrosystem development), may have reduced "natural cover" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining). The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable lubricants" where feasible.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF in the Action Area
		Increased exposure of yearling SR fall Chinook salmon to TDG in the lower Snake and Columbia Rivers and at least 35 miles below Bonneville Dam during involuntary and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor. The incidence of adverse effects appears to have been small (1 to 2 percent) in recent years with TDG up to 120 percent. Most subyearling and all adult SR fall Chinook salmon migrate through the mainstem after the spring spill period ends in mid-June. The existence and operation of the hydrosystem has reduced safe passage by creating conditions that delay and injure/kill some juveniles and a smaller proportion of adults in the migration corridor. However, safe passage has increased substantially for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring and summer juvenile outmigration periods. Small increases in obstructions for adult fall Chinook salmon during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past the dams or overwintering within the fish facilities or turbine units). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile fall Chinook salmon because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems). Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Increased opportunities for avian and fish predators in the tailraces of mainstem dams. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, propane cannons, and limited amounts of

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF in the Action Area
		lethal take. Fish predation is addressed by dam angling at several dams. Delays of adults at the ladder entrances at Bonneville Dam has increased the risk of pinniped predation (excessive predation related to hydrosystem development and operation) in the migration corridor. Pinniped predation is addressed by the use of sea lion excluder devices at the fishway entrances at Bonneville Dam. Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling Chinook salmon by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the Caspian Tern Management Plan on East Sand Island is reducing excessive predation on juvenile Chinook salmon in the migration corridor, but depending on ocean conditions and compensatory effects, may not be increasing adult returns for SR fall Chinook salmon. Implementation of the Double-crested Cormorant Management Plan may have contributed to or at least coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

Habitat conditions in much of the lower Snake river basin within the Interior Columbia Recovery Domain have been significantly degraded by an array of land uses, including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats for SR fall Chinook salmon, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions in spawning and rearing areas (NMFS 2017h, NWFSC 2015). In combination, the degraded conditions in these basins contribute, either directly or indirectly, to impaired habitat in the lower reaches of major tributaries (e.g., lower Clearwater River, lower Grande Ronde, Imnaha, Tucannon Rivers, etc.) where fall Chinook salmon spawn and rear.

Historically important habitat was blocked by the construction of the Hells Canyon Complex and other mainstem dams built without fish passage (safe passage in juvenile and adult migration corridors). Since 1991, the Idaho Power Company, which operates the Hells Canyon Complex, has provided stable flows for spawning fall Chinook salmon from mid-October to early December, minimum flows through the winter and early spring to protect incubating eggs and emerging fry, and measures to reduce entrapment. However, low dissolved oxygen levels in the late summer and early fall, elevated TDG levels in winter and spring, and altered flows continue to limit the functioning of spawning and rearing areas in this reach.

Habitat quality of migratory corridors in this area was substantially affected by the development and operation of the CRS dams and reservoirs in the mainstem lower Snake and Columbia Rivers, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and upper Columbia River basins. Hydrosystem development modified natural flow regimes, resulting in warmer late summer/fall water temperatures. Changes in fish communities led to increased rates of predation on juvenile salmon and steelhead. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines and juvenile bypass systems have also killed some outmigrating fish (NMFS 2017h). However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented measures in the juvenile and adult migration corridors, including a summer spill program, surface passage routes, upgrades to juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

In addition, basinwide water management activities, including the operation of the CRS water storage projects for flood control, power generation, and water withdrawals have substantially reduced average monthly flows at Bonneville Dam during May to July and increased them during October to March compared to an unregulated system. Reduced spring flows, combined with the existence of mainstem dams, increased travel times during the juvenile outmigration period for yearling SR fall Chinook salmon, increasing the risk of predation. Since salmon and steelhead were listed and critical habitat was designated under the ESA, the Action Agencies have made substantial changes to minimize these operational effects by limiting storage reservoir elevations to minimums needed for flood risk management and passing more water during the spring refill period. By taking these actions, the Action Agencies have increased flows in the spring and summer, which helps replicate the natural hydrograph. As a result, the functioning of the migration corridor has been improved by reduced exposure to predators, increased turbidity (which can provide visual cover), and increased access to cover and prey in nearshore mainstem habitat.

The functioning of juvenile rearing and migration habitat for SR fall Chinook salmon in the lower Columbia River estuary has been reduced by the conversion of more than 70 percent of the original marshes and spruce swamps to industrial, transportation, recreational, agricultural, or urban uses. Water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. Reduced sediment delivery to the lower river and estuary, combined with in-water structures that focus flow in the navigation channel and bank armoring, have altered the development of habitat along the margins of the river. All of these changes have reduced the availability of prey for smolts between Bonneville Dam and ocean entry.

In the hydrosystem reach, altered habitats in project reservoirs and tailraces create more favorable habitat conditions for fish predators; the latter include native northern pikeminnow and non-native walleye and smallmouth bass. The effects of the non-native species and those of pikeminnow, to the extent they are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea lion predation on adult SR fall Chinook salmon in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary has increased, but is a natural phenomenon and therefore not excessive predation in the context of effects on the functioning of critical habitat.

Restoration activities addressing habitat quality and complexity, migration barriers (e.g., summer spill, new surface passage structures, and improved spillway designs), and water quality have improved the baseline condition for PBFs. However, the role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the ESU. More restoration is needed before the PBFs can fully support the conservation of SR fall Chinook salmon.

2.5.2.9 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of SR fall Chinook salmon, including recent biological opinions issued for SR fall Chinook salmon and key emergent or ongoing habitat concerns (NMFS 2016b). From January 2015 through May 22, 2020, we completed 431 formal consultations that addressed effects to SR fall Chinook salmon.[187] These numbers do not include the many projects implemented under programmatic

[187] PCTS data query July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Because SR fall Chinook salmon are primarily mainstem spawners, tributary habitat improvement actions are generally not targeted to benefit them. However, there is some potential that habitat improvement actions targeted at SR spring/summer Chinook salmon and steelhead spawning and rearing habitat could benefit habitat in the lower reaches of the Tucannon, Grande Ronde, Imnaha, Salmon, and Clearwater Rivers, where some SR fall Chinook salmon spawn. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., safe passage in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.5.2.10 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of SR fall Chinook salmon. Recent improvements in passage conditions at mainstem CRS dams, cool water releases from Dworshak Dam during the summer to moderate temperatures in the lower Snake River, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, tributary habitat improvements that improve flow, water quality, and reduce sediment in the lower reaches of tributaries, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. The recovery plan (NMFS 2017h) identified blocked habitat, hydropower, tributary habitat, estuary habitat, harvest, hatcheries, predation, and exposure to toxic contaminants, and the effects of climate change and ocean cycles as limiting factors that continue to negatively affect SR fall Chinook salmon.

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for SR fall Chinook salmon, as described above. The PBFs essential for the conservation of SR fall Chinook salmon include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River).

The Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of some of these PBFs of critical habitat. Recent surface passage improvements are expected to reduce delay and mortality of juvenile fall Chinook salmon at mainstem dams. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. Similarly, projects that have protected or restored tributary habitat (that affects the lower segments of the tributaries in which fall Chinook spawn and rear) have improved the functioning of the freshwater spawning and rearing sites. However, the factors described above continue to have negative effects on these PBFs.

2.5.3 Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020; Section 2).

2.5.3.1 Effects to Species

2.5.3.1.1 Spill and Seasonal Flows Operations

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams. The intent of flexible spill operations is to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem.[188] Spring spill operations will occur from April 3 to June 20 at the four lower Snake River projects and from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, the four lower Snake River dams and McNary Dam will all operate up to 125 percent TDG spill ("gas cap spill") for a minimum of 16 hours per day, and each project may operate under lower spill levels ("performance standard spill") for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill at all hours. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs maximum spill constraint) for 16 hours per day with 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours; however, once the trigger for adult SR spring/summer Chinook salmon passing Lower Monumental Dam is met,[189] 8 consecutive hours of performance standard spill will be used in the morning at Little Goose Dam to help reduce passage delays of adult SR spring/summer Chinook salmon.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan, unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in performance standard spill periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.5-8.

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[188] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

[189] A passage trigger of 25 adult SR spring Chinook passing Lower Monumental Dam was implemented in 2020 per the Flexible Spill Agreement.

Table 2.5-8. Spring spill operations at lower Snake and Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3, 5]	Performance Standard Spill (8 hours per day)[2, 4, 5]
Lower Granite[5]	125% Gas Cap	20 kcfs
Little Goose[6, 7]	125% Gas Cap	30%
Lower Monumental	125% Gas Cap (uniform spill pattern)	30 kcfs (bulk spill pattern[8])
Ice Harbor	125% Gas Cap	30%
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[9]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[10]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility (with the exception of Little Goose and Lower Granite operations described in the notes that follow). Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions, except as noted below.

[5] Lower Granite Exception One - If adult passage delays are observed at Lower Granite Dam, the Corps may implement performance standard spill at Lower Granite Dam for at least 4 hours in the AM (beginning near dawn). Implementation of this modification may also trigger in-season reevaluation of options to balance power principle.

[6] Little Goose Exception One - As soon as practicable (and, in any event, no more than 24 hours) after a cumulative total of 25 adult spring Chinook salmon (not including jacks) pass Lower Monumental Dam, operate Little Goose spill at 30 percent spill for 8 consecutive am hours (April 1 to 15, start at 5 AM; April 16 to June 20, start at 4 AM).

[7] Little Goose Exception Two - During periods of involuntary spill, spill at 30 percent for 8 hours/day during the hours described in footnote 6 above and store additional inflows that exceed hydraulic capacity in the forebay above MOP if necessary. When it is necessary to pond water to achieve the lower spill levels due to high inflow, water stored above MOP should be drafted out over the remaining hours by increasing spill to pass inflow from 1200 to 1600 hours (or 1300 to 1700 hours from April 3 to 15), then increasing spill as necessary from 1600 to 0400 (or 1700 to 0500 hours from April 3 to 15) to draft the pool back to MOP. If it is forecast that the drafting spill will generate TDG levels in the tailrace in excess of 130 percent TDG, use all 16 hours to return the pool to MOP.

[8] If the specified spill level at bulk pattern exceeds the gas cap, then spill pattern will be changed to uniform.

[9] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[10] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 21 to August 31 at the four lower Snake River projects, and June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.5-9. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Snake and Columbia Rivers. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.5-9. Target summer spill levels at lower Snake and lower Columbia River projects.

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
Lower Granite[2,3]	18 kcfs	Removable spillway weir or 7 kcfs
Little Goose[2,3]	30%	Adjustable spillway weir or 7 kcfs
Lower Monumental[2,3]	17 kcfs	Removable spillway weir or 7 kcfs
Ice Harbor[2,3]	30%	Removable spillway weir or 8.5 kcfs
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[4]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] Spill levels may not be achievable on all hours if water is stored or flows are below 20 kcfs, which can occur in the month of August, especially at Lower Granite and Lower Monumental Dams when flows are at or below 30 kcfs (see FOP for additional information).

[3] Summer spill from August 15-August 31 may be through the spillway weir or through conventional spillbays using the appropriate FPP spill pattern for each project. The spillway weirs will be operated consistent with operational criteria in the FPP.

[4] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March; decreased flows from May through August, and little change in flows in April and September) described in the Environmental Baseline section will continue to affect the lower Snake and lower Columbia mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in all project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce high TDG events associated with spill in the winter, which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. The proportional effect on flow is higher in the lower Snake River than in the lower Columbia River due to its smaller flow volume. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.5-7).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

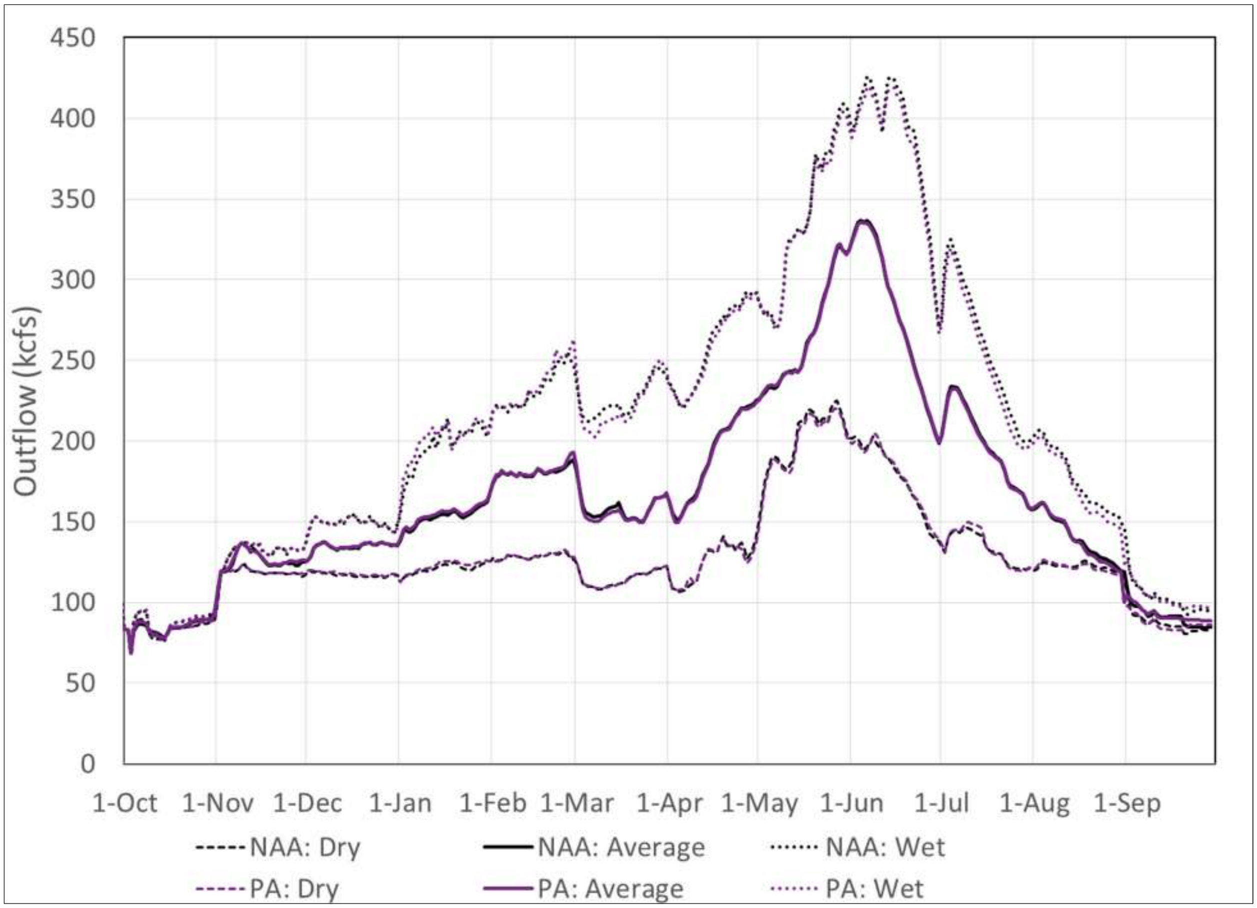

Figure 2.5-7. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

Juvenile SR fall Chinook salmon migrate through the lower Snake and Columbia Rivers primarily in April to early-May (yearlings) or late-May to July (subyearlings). The Action Agencies operate to meet seasonal flow objectives to support juvenile migrants during those periods. Adult SR fall Chinook salmon migrate primarily in late-August to early-November. The proposed change in flow would be too small to affect river temperature during the adult summer migration period, which would be the attribute of highest concern. The associated effects on SR fall Chinook smolts or adults should not change from recent conditions by a meaningful amount.

The effects of the proposed hydrosystem operations and the non-operational measures on SR fall Chinook salmon and its habitat are described below.

2.5.3.1.2 Water Quality

The operation of the CRS will continue to affect water quality parameters in the mainstem migration corridor. This includes delayed spring warming, delayed fall cooling, reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs, and the continued releases of cool water from storage at Dworshak Dam to moderate lower Snake River water temperatures from June through September.

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacity spill. These events occur most frequently in May and June but may also occur other months.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spring spill operation would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. This would affect all subyearling and yearling smolts migrating in the river between April 3 and June 20 in the Snake River and April 10 to June 20 in the lower Columbia River. In recent years, approximately half of SR fall Chinook salmon smolts pass Lower Granite Dam by early June, though there is interannual variation in their juvenile outmigration timing. Smolts migrating after June 20 would not be affected by the flexible spring spill operation, but may be affected by spill reduction in August. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020). Data from all fish sampled in the CRS Gas Bubble Trauma Monitoring Program (1996 to 2019) indicate that signs of GBT were almost non-existent below 120 percent TDG, increased slightly between 121 and 125 percent TDG, and then increased in incidence and severity when TDG levels exceeded 125 percent (FPC 2019). The available information in Zabel (2019) and Widener et al. (2020) suggests that the relatively high TDG exposure often exceeding 125 percent during high flow years (e.g., 2006 and 2011) did not reduce Snake River spring-summer Chinook smolt survival through the CRS, and would therefore be unlikely to reduce the survival of SR fall Chinook salmon migrating during the spring spill season. However, many factors besides TDG levels (e.g., fish condition, route of passage, etc.) can influence reach survival estimates. Thus, the proposed flexible spring spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms from elevated TDG, but no measurable decrease in juvenile survival.

Adult SR fall Chinook salmon migrate in the late summer and fall between Bonneville and Lower Granite Dam and will not be affected by the flexible spring spill operation.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[190] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (EPA 2018, Perhar and Arhonditsis 2014). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on SR fall Chinook salmon are likely to be very small and are not expected to detectably affect reach survival estimates.

Sediment Transport

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the

[190] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

spring freshet. The increased water transparency hypothetically increases the exposure of SR fall Chinook salmon juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile SR fall Chinook salmon may spend days to months in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

2.5.3.1.3 Project Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems (BPA et al. 2020). Maintenance activities evaluated and covered under this opinion can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance, as summarized in Section 1.3 of this opinion and in further detail in BPA et al. (2020).

Fishway structures (e.g., fish ladders, screens, bypass systems) will be routinely maintained and temporarily removed from service on a scheduled basis during the established in-water work period (December to March), in accordance with the Fish Passage Plan and coordinated through FPOM to minimize impacts to adult and juvenile migrants. At Bonneville Dam, routine dredging in the forebay and rock removal in the spillway will occur every year or two to ensure reliable operation and structural integrity of the fishways. Turbine unit maintenance is planned at all dams and will be coordinated through FPOM to minimize and avoid delay, injury, and mortality.

Routine outages of fishways are necessary to maintain reliability, but these temporary outages can cause delay and mortality for adult and juvenile migrants that attempt to migrate at the time of the outage. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be relatively low numbers of Snake River fall Chinook salmon that are present, and these effects will occur at low levels similar to what was observed in the recent past. Passage delay and conversion rates will be monitored and maintenance/contracting schedules may be modified through FPOM or adaptive management if evidence indicates elevated delay and mortality are occurring.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization and major rehabilitations. Non-routine maintenance expected in the timeframe of the proposed action includes the installation of improved fish passage (IFP) turbines at three out of six turbine units at Ice Harbor Dam. At McNary Dam, turbine replacement is expected to begin within the next 15 years. At John Day Dam, turbine replacement may begin, but it is uncertain at this time if it will be completed, within the 15-year period of the proposed action. The proposed maintenance at Grand Coulee could result in outages and additional spill in limited situations, but changes to total outflows are not expected. The Corps will repair the existing jetty and retaining wall located near the north shore adult ladder entrance at Little Goose Dam, where significant erosion has occurred. Replacing the jetty with large rock and/or large coffer cells will restore passage conditions at the north shore ladder entrance when spill exceeds 30 percent at Little Goose Dam. Non-routine maintenance (related to turbines or spillbays) expected in the proposed action can increase TDG during uncontrolled spill by temporarily reducing powerhouse capacity and may cause suboptimal tailrace conditions which can delay passage. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce risk to adults and juveniles.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated with NMFS and through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize negative effects on fish. Fish passage metrics will be monitored with counts and PIT tags to ensure unscheduled maintenance activities do not result in negative impacts to the ESU.

Overall, scheduled maintenance activities are expected to continue to negatively affect small numbers of adult Snake River fall Chinook salmon annually. A few adults will be delayed or die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. Most juveniles will not be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled, but relatively low numbers of early migrating or overwintering juveniles may be affected. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile Snake River fall Chinook salmon may continue to result in increased TDG exposure and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes will continue to minimize the impacts.

2.5.3.1.4 Adult Migration/Survival

For SR fall Chinook salmon, the effects of operating the hydrosystem as proposed will generally be consistent with recent operations and mitigation measures, except that the Action Agencies will reduce voluntary summer spill at the lower Snake River and lower Columbia River dams from August 15 to 31.

Recent (2010 to 2019) estimates of adult SR fall Chinook salmon survival rates from Bonneville to Lower Granite Dam have averaged about 90 percent. Adult SR fall Chinook salmon will not be affected by the proposed flexible spring spill operation because they migrate after June 20, when voluntary spring spill will end. A small increase in adult mortalities could occur as a result of adults ascending the ladders but then falling back through the turbines at Snake River dams[191] in August, when spill is reduced. However, these losses would not be expected to substantively affect survival rates. There should be no substantial effect on adult migrants, as their migration timing (late summer and fall) does not appear to be affected by the dams and reservoirs (Ferguson et al. 2005) and they are not exposed to predators (other than fisheries) upstream of Bonneville Dam.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14, unless adjusted due to (rare) low flow occurrences in the Snake River to meet authorized project purposes. Maintaining the increased operating range by 6 inches at the lower Snake River dams (MOP 1.5-foot range) as implemented in 2019 and 2020 has not yet been fully evaluated under a range of flow years. The increase in operation range is expected to slightly reduce the average flow rate in the reservoirs, but the flow change is minimal and is not expected to affect adult migration timing or survival rates.

The Action Agencies propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP (262.5 to 264.5 feet), except during the spring spill period, when the John Day forebay operating elevation window will be increased. From April 10 to June 1–15, John Day Reservoir elevation will be held between 264.5 feet and 266.5 feet to deter piscivorous Caspian terns from nesting in the Blalock Islands Complex (see Section 2.2.3.1.10). Following this operation, John Day Reservoir elevation would return to MIP + 2 feet operation through August 31. The increase in operating range is expected to slightly reduce velocities in John Day Reservoir, but the velocity change is not expected to affect adult migration timing or survival rates because adult SR fall Chinook will not be migrating in John Day Reservoir when this occurs.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. PIT-tag and passage data indicate that fewer than 10 percent of adult SR fall Chinook salmon migrate through the Snake River during this time period, so we expect there could be a small (hours or days) effect on adult migration timing for these individuals, but we would not expect these delays to measurable impact adult survival rates.

[191] Many adults falling back at Lower Granite or Little Goose Dams are fish that overshoot Lyons Ferry Hatchery and then voluntarily fall back to return to the hatchery.

Because adults migrate in the fall, allowing turbine units to operate above the 1 percent peak efficiency range under limited conditions and for limited durations is expected to occur during higher flows in the spring and early summer and should have no effect on adult SR fall Chinook salmon.

Overall, these factors (which individually have small positive or negative effects) should have no measurable effect on overall adult survival rates. Therefore, the recent survival rates (about 90 percent) from Bonneville to Lower Granite Dams would be expected to continue under the proposed action.

2.5.3.1.5 Juvenile Migration/Survival

Understanding how hydrosystem operations affect juvenile SR fall Chinook salmon is complicated by their diverse life history strategies. PIT-tagged juvenile SR fall Chinook salmon detected at Little Goose Dam (2014 to 2019) from April to mid-May were dominated by yearling migrants that overwintered in Little Goose or Lower Granite reservoir, or in the lower Clearwater River upstream (Figure 2.5-8). Many of these fish are from the Clearwater River major spawning group, where juveniles emerge later because of cooler incubation temperatures. In contrast, juveniles migrating past Little Goose Dam from mid-May through August 31, the end of the juvenile spill season, are nearly all subyearling fall Chinook that emerged from the gravel in March through May of the same year. Juveniles from the Upper and Lower Hells Canyon and Grande Ronde major spawning groups make up the majority of migrants in the early part of this timeframe (mid-May through mid-July); later in the summer juveniles from the Clearwater River become most abundant. Similar patterns in the timing of juvenile PIT-tag detections are observed at the lower Columbia River dams.

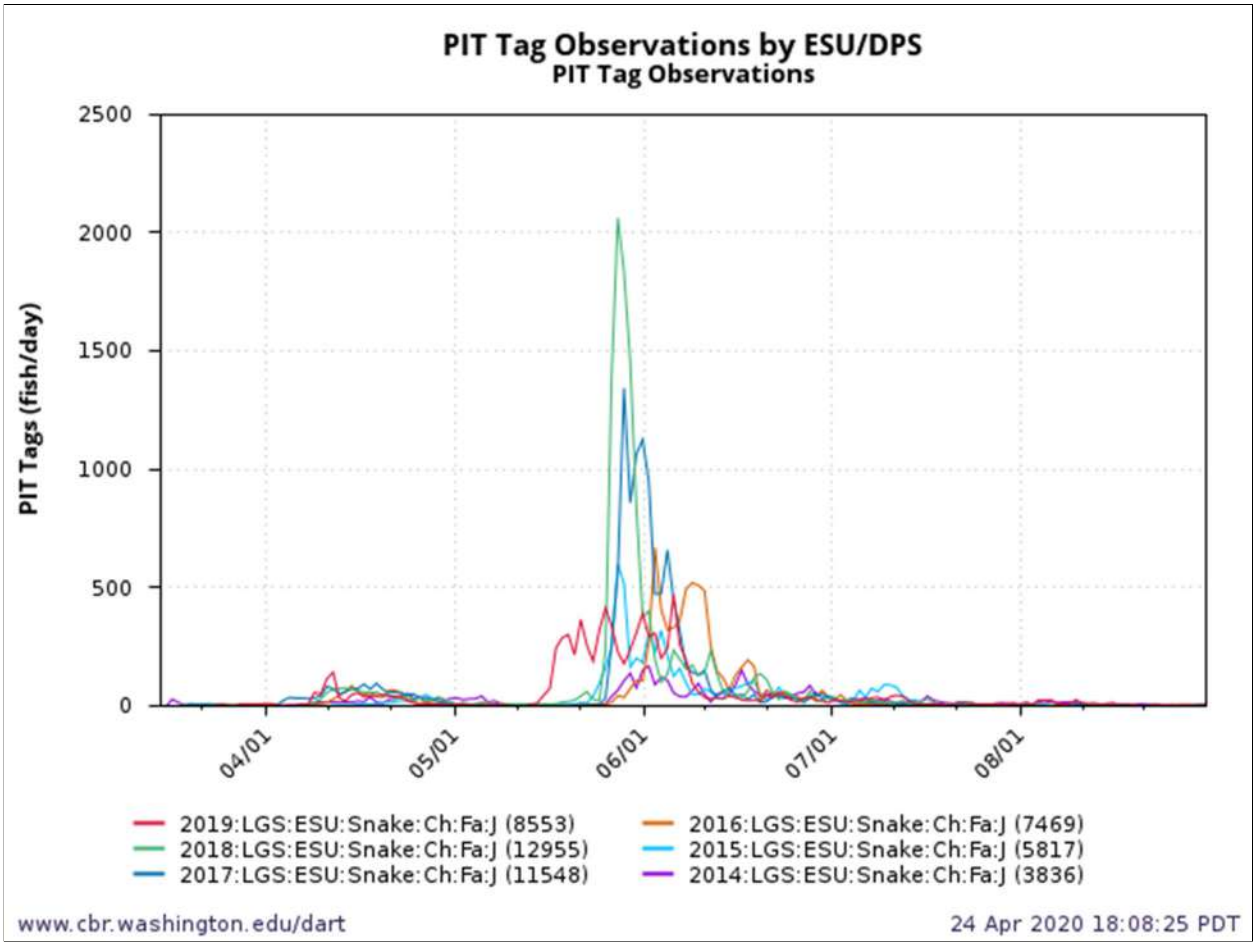

Figure 2.5-8. Detections of natural-origin and hatchery juvenile SR fall Chinook salmon at Little Goose Dam from 15 March to 31 August (2014 to 2019). Source: Columbia River DART, downloaded 24 April 2020 (DART 2020f).

The Action Agencies propose to continue to provide fish passage spill (conventional and surface passage), operate juvenile bypass systems, and implement other operations (e.g., ice and trash sluiceways, Bonneville corner collector, etc.) for juvenile passage at the eight lower Snake and lower Columbia River dams. Surface passage structures and juvenile bypass systems exist at all four of the lower Snake River dams, and surface passage structures exist at each of the four lower Columbia dams, and three of them have juvenile bypass systems. The Dalles Dam does not have a juvenile bypass system because of low powerhouse passage rates. Increased spill levels resulting from the flexible spring spill operations are expected to have little negative effect on tailrace conditions at Bonneville, The Dalles, McNary, and Ice Harbor Dams, but could cause eddies to form at other dams under low to moderate flow conditions. The latter would likely increase the exposure to predators of juvenile SR Chinook salmon passing through the spillway, thereby reducing spillway survival by a small, but unknown, amount. Increased spill levels at the other dams (excepting The Dalles Dam which will continue spilling at 40 percent) would generally be expected to slightly increase direct dam passage survival rates of inriver migrating smolts as spillway survival rates generally exceed those in the juvenile bypass systems or through the turbine unites. Overall, the survival of inriver migrating juvenile SR Chinook salmon from all populations and MPGs should increase slightly as a result of implementing the flexible spring spill levels at each of the eight mainstem dams. Increases in downstream migration survival are expected to increase population productivity by delivering more smolts to the ocean, resulting in more adults returning.

The proposed flexible spring spill operations will reduce travel times, increase exposure to TDG, increase the proportion of juveniles going over spillways, reduce transportation rates, and degrade tailrace egress conditions. While juvenile fall Chinook salmon migrating in May and June might show an increase in GBT symptoms, overall survival rates should be maintained or potentially increased for juvenile migrants during the spring spill season. Also, to the extent that latent mortality might be improved by reduced powerhouse passage, as is hypothesized by the CSS for SR spring/summer Chinook salmon, there is potential for additional increased productivity.

Survival rates for juvenile fall Chinook salmon migrating during the summer spill season should be similar to the increased levels observed in the past decade. The Action Agencies propose to continue 24 hour spill programs during the summer, but reduce spill at the eight mainstem dams from August 15 to 31. Most SR fall Chinook salmon juveniles, both subyearlings and yearlings, will have migrated through the system by late August. A few migrants, especially those from the Clearwater River spawning group, would still be migrating and would be affected by reduced summer spill in late August. Reduced spill would be expected to decrease survival for migrating juveniles because fewer fish will pass these projects using the spillway, and tailrace egress conditions will be poor. However, because of the small numbers of migrants and the likely small magnitude of reductions in survival, reducing spill for two weeks should not affect the overall productivity/abundance or spatial structure or diversity of either the Clearwater River major spawning group, or to the single-population ESU as a whole, especially given that about 75 percent of the adult spawners in the major spawning areas are of hatchery origin (Lyons Ferry Hatchery or closely related programs).

SR fall Chinook salmon smolts will continue to be collected for transport at the three Snake River collector projects. The increased spill will result in more juvenile fish going over the spillway and fewer fish being transported on a given date. This effect will be especially pronounced in low to medium flow years. Assuming a continued overall benefit of transport for SR fall Chinook, the expected decrease in transport rates resulting from increased spill at the three collector projects would, on average, result in a slight reduction in adult returns. The slight reduction in adult returns could be offset if increased spillway passage decreases latent mortality.

The proposed cessation of transport from June 21 to August 15 will reduce the proportion of fall Chinook transported relative to recent years when transport continued throughout the summer, ending at the end of September (Lower Monumental Dam) or October (Little Goose and Lower Granite Dams). This would likely reduce the number of returning adults by some amount as T:B ratios typically favor transported fish during this time. Relatively few fish are passing the collector projects during this time, and juveniles from the Clearwater River major spawning group are likely to be most abundant, and so most affected. Decisions on the specific dates for stopping and then restarting transportation in the summer would remain subject to the TMT and FPOM processes and recommended dates could change if new information suggests it would improve SR fall Chinook SARs. In sum, while the productivity and abundance of SR fall Chinook salmon, especially the Clearwater River major population group, would be slightly reduced by ending transport from June 21 to August 15, it would not be expected to appreciably affect the overall productivity or abundance of the ESU.

The Action Agencies also propose to increase operational flexibility by maintaining the increased pool elevation limits at the Snake River dams (MOP 1.5-foot range) and at John Day Dam (MIP 2-foot range). McNary, The Dalles, and Bonneville Dams will be operated within the normal forebay operating range for each project. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP level, except during the spring spill period when the John Day forebay operating range will be increased. From April 10 to June 1–15, the elevation of John Day Reservoir will be held between 264.5 feet and 266.5 feet to deter Caspian terns from nesting in the Blalock Islands Complex (Section 2.5.3.1.9). Following this operation, the elevation of John Day Reservoir would return to MIP + 2 feet operation through August 31. The increase in operation range is expected to slightly reduce velocities in John Day Reservoir (and continue the recent, slight reductions in velocities in the Snake River reservoirs), increasing travel times compared to the recent averages, but this should be substantially offset by higher spill levels which should reduce travel times during the spring spill period.

The proposed operations at Libby Dam, Hungry Horse Dam, Grand Coulee Dam, and Dworshak Dam will alter flows by less than 2 percent during the spring migration period. This would be expected to result in very small increases in travel times in April and May, and small decreases in travel times in June, but should not measurably affect juvenile survival. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. These operations will result in no flow past the projects in the Snake River during these periods. Some overwintering juvenile fall Chinook are expected to be in the lower Snake River during this period, however, these temporary flow changes are not expected to measurably affect the juvenile migration timing or survival of these fish.

Power generation at Snake River projects may cease for short periods between October 15 and February 28 and will result in no flow past the projects in the Snake River during these periods. Zero or very few SR fall Chinook salmon juveniles are expected to be actively migrating through the lower Snake River during this period, so this operation will have no measurable effect.

As described above (see Section 2.5.3.1.4), under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, but the number of juveniles affected should be extremely low because of the short time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure, would slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, and would slightly increase powerhouse passage rates of juvenile SR fall Chinook salmon, particularly for yearling fall Chinook and early subyearling migrants. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams from April through June. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of SR fall Chinook between Bonneville Dam and Lower Granite Dam, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population level as a result of the proposed turbine unit operations above 1 percent peak efficiency range, especially considering the increased volumes of spill occurring as a result of the flexible spill operation in April, May, and June. Juvenile SR fall Chinook salmon migrating after June will not be affected by these operations.

Overall, the proposed action should generally maintain or improve inriver survival rates for juvenile SR fall Chinook salmon for four of five major spawning aggregates. Juvenile survival rates during Flexible Spring Spill operations could increase slightly, and if adult returns increase at a level similar to those hypothesized by the CSS for SR spring/summer Chinook (35 percent) or SR steelhead (28 percent), adult return rates would be expected to increase substantially for those fish migrating prior to June 20. Later migrants should generally continue to survive at the improved rates noted in the past decade, but some slightly reduced survival rates, especially for juveniles from the Clearwater River major spawning group, are likely to result from the proposed August spill reduction. Increased spill levels (reduced transportation rates) would be expected to increase adult returns for juveniles migrating past the three Snake River collector projects prior to June 20 when T.B ratios tend to favor inriver migrants. Transport cessation from July 1 to August 15 would somewhat reduce the number of returning adults, especially for the Clearwater River major spawning group, which is most likely to be migrating later in the summer, when T:B ratios tend to favor transported fish. However, relatively few fish (from either the Clearwater River major spawning group, or the other four major spawning groups) are migrating during this period, so the overall effect on adult returns would be small. Cool water releases from Dworshak Dam will continue to support juveniles rearing in the reservoirs during the summer and early fall. Slightly elevated reservoirs should have relatively small effects on travel times (hours) that would not be expected to measurably affect survival rates.

2.5.3.1.6 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). Program goals are to increase the extent and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to SR fall Chinook salmon as they migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty about predicting the availability of habitat restoration actions into the future and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the CEERP component that provides a basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the action effectiveness monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program will confirm that these floodplain reconnections are enhancing conditions for salmonids such as SR fall Chinook salmon, or will provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action and beyond.

With all of these program elements in place (rolling five-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change considerations and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate for the effects of mainstem flow management which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the flux of insect and amphipod prey to the mainstem migration corridor for juvenile SR fall Chinook salmon. It is also reasonably certain that these benefits will increase as habitat quality matures, contributing to increased abundance, productivity, and life-history diversity[192] of the SR fall Chinook salmon population, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.5.3.1.7 Tributary Habitat

There are no tributary habitat actions specifically targeted to improve spawning and rearing habitat conditions for SR fall Chinook salmon in the proposed action. There is some potential that habitat improvement actions targeted at SR spring/summer Chinook salmon and steelhead spawning and rearing habitat could benefit habitat used by SR fall Chinook salmon in the lower reaches of the Tucannon, Grande Ronde, and Clearwater Rivers (three of five major spawning areas), but those effects (e.g., reduced sediment, improved flows, etc.), would be small and not have substantial benefits to SR fall Chinook salmon.

2.5.3.1.8 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e, so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail in the site-specific biological opinions referenced therein (see Section 2.5.2.2). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g.,

[192] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile Chinook salmon opportunities to move into wetland habitats for food and refuge from predators. Moreover the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of the SR fall Chinook salmon ESU.

outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.5.3.1.9 Predation Management

Avian Predators

Avian Predators in the Lower Columbia River Estuary

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions are likely to continue current levels of predation at these colonies, which, in the case of Caspian terns, is an average annual reduction of 1.9 percent from the pre-colony management period. However, ocean conditions, including compensatory effects such as the number and behavior of predators and competition for prey, will determine whether this reduction in tern predation influences adult returns. Although there appears to have been a small decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 4.2 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, cormorant predation in the estuary may be an increasingly important source of mortality for SR fall Chinook salmon.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

Avian Predators in the Hydrosystem Reach

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia and Snake River dams. At each dam, bird numbers will continue to be monitored, birds foraging in dam tailraces will be hazed (including, in some circumstances, lethal reinforcement), and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas and juvenile bypass outfall areas, will also continue. If proven biologically and cost effective, the Corps will deploy laser systems to haze birds foraging near bypass outfalls. Upgrades to existing systems, including bird wires at McNary Dam, will be coordinated through the FPOM and included in the annual Fish Passage Plans. We expect that these measures will continue to reduce predation on juvenile SR fall Chinook salmon, although Zorich et al. (2012) were unable to quantify the amount of protection.

The Action Agencies propose to continue to address tern predation at lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. These measures are likely to preclude use of Crescent Island by Caspian terns. Reclamation will continue passive and active dissuasion efforts for Caspian terns on Goose Island. They have coordinated the timing and duration of the proposed work with USFWS to ensure it will be effective in maintaining the management objectives of fewer than 40 breeding pairs at this site, consistent with the IAPMP. This ongoing suite of colony management actions is likely to continue current levels of predation by terns in the interior Columbia River basin, which have contributed to observed levels of abundance and productivity for the single population of SR fall Chinook salmon, which is a small improvement compared to the pre-colony management period.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the hydrosystem reach are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

John Day Reservoir—Spring Operations to Reduce Predation Rates by Caspian Terns

The Action Agencies propose to hold the elevation of John Day Reservoir at 264.5 to 266.5 feet from April 10 to June 1 or not later than June 15 each year, or as feasible based on river flows, to inundate bare sand habitat and deter Caspian terns from nesting in the Blalock Islands Complex. Because foraging effort and predation rates increase once chicks hatch, the Action Agencies will begin to increase the reservoir elevation before Caspian terns initiate nesting (i.e., operations may begin earlier than April 10). The Action Agencies will consider bird observations along with the run timing of juvenile steelhead to determine the dates each year. At the conclusion of this operation, the draft to operating range (262.5 to 264.5 feet) will be completed within 4 days. In general, 95 percent of the juvenile steelhead migration passes John Day Dam by June 1 (DART 2020m).

The timing of this operation is based on the expectation that Caspian terns will begin colonizing exposed habitat and start courtship and nest building within days to weeks of returning the reservoir to the 262.5 to 264.5-foot range. In general, chicks hatch about 27 days after eggs are laid, at which point energetic demands and fish consumption rates increase substantially. We expect that inundating bare sand habitat until after 95 percent of yearling steelhead pass John

Day Dam will maintain the recent low predation rates (less than 0.1 percent) on spring-migrating juveniles from the SR fall Chinook salmon ESU.

Fish Predators

The NPMP's Sport Reward Fishery, or a similar removal effort, will continue as part of the proposed action. The current fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the average number of Chinook salmon, including some SR fall Chinook salmon, that will be handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy), will be no more than 100 adults (including jacks) and 200 juveniles per year. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams and will conduct test fisheries at additional dam projects on the Snake River as described in the proposed action (BPA et al. 2020). As the Dam Angling Program evolves and potentially expands, it may help to further reduce predation on juvenile SR Chinook fall Chinook. We estimate that no more than 10 adults (including jacks) and 20 juvenile Chinook salmon, including some from the SR fall Chinook salmon ESU, will be caught in the Dam Angling Program per year.

These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018; Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including SR fall Chinook salmon.

Pinniped Predators

Research indicates Steller sea lions aggregate at Bonneville Dam in the summer and fall to eat adult salmonids and the abundance of Steller sea lions during this period (summer and fall) has increased (Tidwell et al. 2020). The Corps will continue to install, and improve as needed, sea-lion excluder gates at all adult fish ladder entrances at Bonneville Dam each year. The Corps will fund and support dam hazing and dissuasion efforts to effectively reduce predation on adult salmon and steelhead at Bonneville Dam. Dam hazing will be focused on minimizing the amount of time that individual sea lions spend near ladder entrances. Hazing and dissuasion will be supportive of pinniped removal efforts and cover the periods from March 31 through May 31 and August 15 through October 31. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually during the spring winter and fall periods defined in the proposed action (BPA et al. 2020). The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management Coordination Team and the Sea Lion Task Force, to address changing circumstances as they relate to supporting sea lion harassment efforts and monitoring of sea lion predation at Bonneville Dam. These ongoing measures and addition of hazing in the fall are expected to maintain or reduce current levels of sea-lion predation on Snake River fall Chinook salmon in the Bonneville tailrace which we estimate currently ranges from 0.6 to 0.7 percent. If pinnipeds are observed at The Dalles Dam, the Corps may respond with hazing at adult fish ladder entrances.

2.5.3.1.10 Life-Cycle Modeling

NMFS used a life-cycle model, developed by the USGS in coordination with the NWFSC, to assess the effect of proposed hydropower system operations, the effect of continuing hatchery production (in accordance with the most recent HGMPs), and the effect of recent, seasonally variable increases in sea lion predation in the lower Columbia River from the mouth to Bonneville Dam. A time period of 24 years forward from the proposed action was selected as a reasonable timeframe to assess parameters generated by the model, which include the geomean spawner abundance QET. In this model, the abundance estimate is for the number of spawning females, which is a different metric than that used for life-cycle modeling of other populations addressed in this opinion. This is because of the far more limited data available for SR fall Chinook salmon (compared to Snake River spring/summer Chinook salmon), and the complexities arising from the multiple migration strategies and life histories used by this ESU.

The QET is an estimate of the probability of the population reaching a level at which it may be too small to successfully reproduce and is a factor considered in NMFS' viability assessments. Small populations are also more at risk from demographic stochasticity, genetic processes, and environmental variability. Because the exact number at which this condition occurs for Chinook salmon populations is unknown and likely to be reached at population sizes significantly greater than zero, past biological opinions (e.g., NMFS 2008a) provided QET projections for 50, 30, 10, and one individual. The QET estimates the probability that a population falls below the QET 50 (female spawners only) population size for 4 consecutive years. This is because the generation time of Chinook salmon is approximately 4 years, so at any time there are four extant year classes from a basin. If the populations fall below the QET for 4 consecutive years, then all year classes of the population have dropped below the QET. In this opinion, NMFS presents QET projections for 50 adults as a useful means of illustrating differences resulting from factors affecting the modeled populations. More detailed outputs, including QET projections for 30 adults, are presented in Appendix C.

The SR fall Chinook salmon model is a "standalone" model that does not receive inputs from COMPASS or the Ocean Survival models used for SR spring-summer Chinook salmon. Since fall Chinook salmon spawn and rear in mainstem rivers, proposed tributary habitat improvements were not included in the model.

A full description of the first version of this model can be found in Zabel et al. (2017). Since that report, numerous changes and advances have been made in the model that will be detailed in a forthcoming report (Tiffan and Perry 2020). These changes include:

- Using a newly published temporally stratified mark-recapture model to estimate abundance and passage timing of juvenile fall Chinook Salmon at Lower Granite Dam (Hance et al. 2019).
- Using a Beverton-Holt stock recruitment function for the spawner-to-juvenile stage.
- Estimating SAR rates separately for subyearling and yearling outmigrants based on scale analysis that identifies juvenile age at ocean entry.

Other model details include the following:

- The model is fitted to 26 years of juvenile and adult abundance estimates (1992 to 2018).
- Recruitment of juveniles is a function of the number of female spawners.
- Broodstock removals, ocean harvest, and inriver harvest downstream of Lower Granite Dam is included in the model; harvest upstream of Lower Granite Dam is not included in the model. Broodstock take of female spawners was set to the mean of the previous 10 years (467 female spawners) if broodstock take was less than 20 percent of the natural-origin females. However, based on recommendations in the hatchery genetic monitoring plan for SR fall Chinook salmon (WDFW 2011), we set broodstock take to a maximum of 20 percent of the abundance of natural origin female spawners.
- Supplementation of hatchery fish was drawn each year from a logit-normal distribution of pHOS based on the previous 10 years of returns (10-year mean pHOS = 0.735, range = 0.64 to 0.86). We also assumed that hatcheries would seek to attain full production by making up the difference in reduced natural broodstock take with hatchery fish. Therefore, we reduced the hatchery spawners by the difference between the 10-year mean natural broodstock take and the realized broodstock take when limited by the maximum 20 percent take.
- Transportation is not currently separated from inriver migration in the model. Thus, SAR is defined as the proportion of the juveniles at Lower Granite Dam from brood year “y” returning as adults to Lower Granite Dam. This means that SAR represents a weighted average survival, with weights being the proportion of transported and inriver migrants. Specifically, the survival components that implicitly form the average SAR include:
    - Hydrosystem survival of inriver migrants between Lower Granite and Bonneville Dams.
    - Survival of transported fish in barges.
    - Survival in the estuary between Bonneville Dam and the ocean (both transported and inriver migrants).
    - Survival in the ocean until return to Bonneville Dam (both transported and inriver migrants).
    - Survival of adults in the hydrosystem between Bonneville and Lower Granite Dams.

The model estimated effects of ocean and hydrosystem covariates on survival parameters during three life-stage transitions: 1) the productivity parameter of the Beverton-holt model for the spawner-to-smolt transition, 2) SAR¬0, smolt-to-adult return rate for subyearling smolts, and 3) SAR¬1, smolt-to-adult return rate for yearling smolts. The model only assumes recent ocean conditions and did not include projections of the effects of climate change on mainstem flows or temperatures, or on ocean conditions for SR fall Chinook salmon.

Results

The model produced estimates of the 10-year geomean of naturally spawning females (hatchery and natural-origin combined) as well as estimates of the likelihood of falling below a QET of 50 spawners. More detailed outputs, including QET projections for 30 adults, are presented in Appendix C.

Estimates of the probability of experiencing QET 50 were at 0 for most of the runs, with a 95 percent likelihood that the risk of QET 50 is less than 5 percent (Figure 2.5-9). Also, given that the model only estimates the abundance of female spawners, the QETs 50 really represent the equivalent of QET 100 compared to modeling conducted for SR spring/summer Chinook salmon. In general, the model suggests a possible slight increase in the number of total spawners, and a low but non-zero probability of the population (of female spawners) falling below the QET 50 threshold.

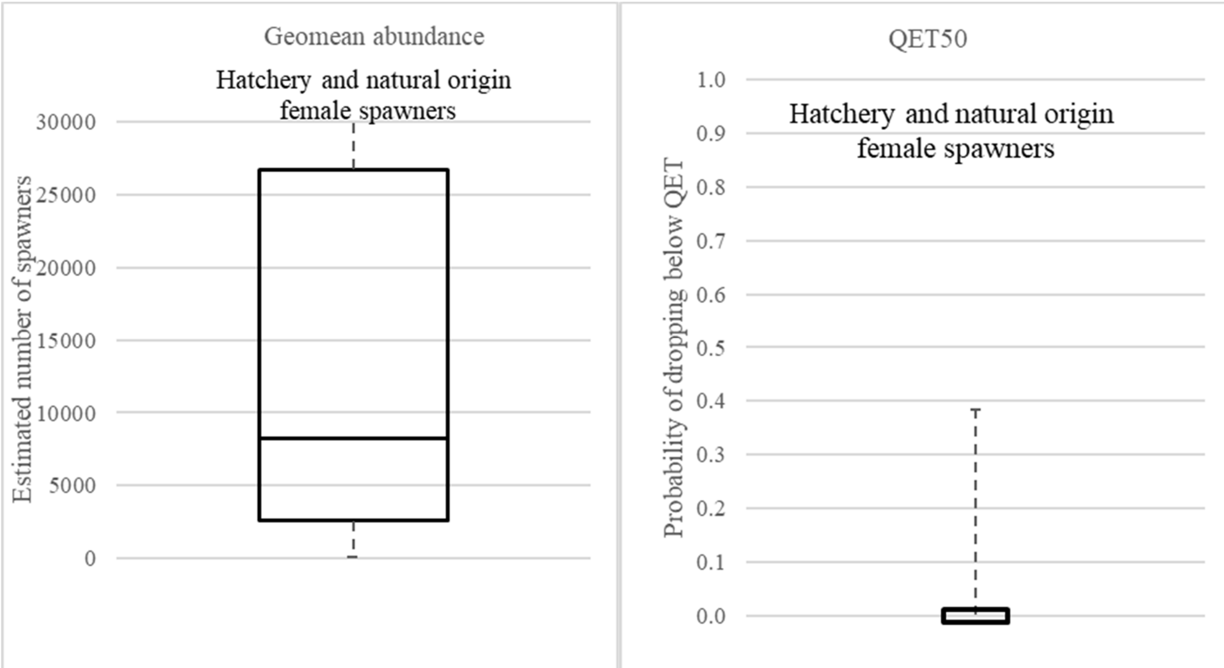

Figure 2.5-9. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 50 (and 25th and 75th percentiles) for the Snake River Fall Chinook ESU of hatchery and naturally produced fish in 24 years (year 15 to 24) under the proposed action. Boxes represent the 25th-75th percentiles, the horizontal line inside the box represents the median (most likely) value, and the "whiskers" represent the 5th and 95th percentiles.

Table 2.2-10. Fall Chinook model outputs for geomean abundance of naturally spawning females (hatchery and natural-origin combined) and likelihood of the population falling below a QET of 50 spawners for quartiles of the distribution of model run results.

Snake River Fall Chinook	Abundance			QET = 50		
Hatchery and natural origin female spawners	25th	Median	75th	25th	Median	75th
	2592	8222	26714	0.00	0.00	0.00

This is the first time that a passage and survival fall Chinook model has been considered in this opinion. Given that it is a new model its results should be interpreted with caution. As with all models it has limitations. Though it did attempt to model the increased spill resulting from the flexible spring spill operation, it does not include a complex mechanistic component, such as COMPASS, to capture the details of proposed operational changes, and it is currently not capable of evaluating specific management or operational changes over time. Further, many factors affecting the survival and adult return of SR fall Chinook salmon are implicitly incorporated into the model (e.g., existence of dams, predation, recent climate change) so the model results do not represent the proposed action alone, but rather the combined effect of the proposed action and all other factors affecting the abundance and productivity of the ESU in the recent past (when data is available). Also, the reasons for the subset of runs (about 5 percent) that predict a declining population (to below QET 50 thresholds) are still under investigation.

Additional complexities with this population that are difficult to capture in modelling are the relatively high harvest rate, broodstock collection, and hatchery supplementation. All of these factors have significant effects on this population, and through appropriate management actions (reduction of harvest and broodstock collection, increased hatchery supplementation) are likely to provide a means to improve conditions if the fall chinook population begins to decline.

Since this model does not include a climate change analysis, such as produced for Snake River spring/summer Chinook, we cannot use it to evaluate the potential effects of this factor. Crozier et al. (2019) assessed SR fall Chinook salmon as having high vulnerability to the effects of climate change. However, fall Chinook should be less subject to some of the expected negative effects of climate change (increased water temperatures, altered flows, and reduced marine survival) than other species because adults can migrate in the late summer and fall, when temperatures are decreasing, and because they spawn in the lower segments of large rivers which are less affected by altered flows. Fall Chinook salmon are also generally more tolerant of higher water temperatures than spring or summer-run Chinook salmon, and because of their predominantly subyearling life history, are better able to avoid high summer temperatures, which may further mitigate, to some degree, the negative effects of increasing summertime water temperatures (see Section 2.5.1.3). Fall Chinook are still likely to be affected by potential decreases in ocean productivity predicted by climate change scenarios (i.e., higher temperatures, increasing acidity, etc.). Marine survival was, by far, the most important factor affecting projected abundance estimates for SR spring/summer Chinook salmon in the next 24 years. However, it is likely that fall Chinook salmon populations will be less affected by climate change than SR spring/summer Chinook salmon (Section 2.2.3.1.12).

2.5.3.1.11 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult SR fall Chinook salmon are likely to be present in shallow shoreline areas, an unknown portion of the ESU will continue to be stunned, harmed or possibly even killed. At present, to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed, and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this ESU that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The present 5-year average number of observed salmonids being stunned and harmed annually by the project is 90,000 juvenile and 1,600 adult salmonids. Some of this take could result in injury or reduced fitness.

These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[193]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. We estimate that, on average, the following number of SR fall Chinook salmon will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS:
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - 145,600 hatchery and 52,325 natural-origin juveniles will be handled.
  - 2,877 hatchery and 613 natural-origin juveniles will die.
- Activities associated with all other RME programs:
  - 4,800 hatchery and 2,000 natural-origin adults will be handled.
  - 50 hatchery and 20 natural-origin adults will die.
  - 225,150 hatchery and 85,675 natural-origin juveniles will be handled.
  - 2,223 hatchery and 987 natural-origin juveniles will die.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RME program will, on average, affect no more than 18.5 percent of the natural-origin adult (recent, five-year average) run (arriving at Lower Granite Dam) and 17.2 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to less than 1 percent of estimated ESU abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the effects of the RME programs on abundance are acceptable and warranted.

[193] Ongoing and future discussions are expected to lead to reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

2.5.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small improvement to safe passage for juvenile SR fall Chinook salmon migrating inriver before June 21. That operation will not affect safe passage in the adult migration corridor because most adults enter the lower Columbia River after June 21. Implementation will also affect the volume and timing of flow in the Columbia River, which alters habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.5-11.

Table 2.5-11. Effects of the proposed action on the physical and biological features (PBFs) of designated critical habitat within the action area for SR fall Chinook salmon.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Spawning and juvenile rearing sites	Lower Snake River reservoir operations will continue to inundate some historical mainstem spawning and rearing habitat (reduced availability of food, riparian vegetation, space). Spill caused by flood-control operations, any turbine unit outages, and lack of load spill at Dworshak Dam will continue to expose redds and incubating juveniles rearing in the lower Clearwater River to increased levels of TDG (reduced water quality in spawning and rearing areas). Reservoir operations at Dworshak Dam will continue to elevate water temperatures in the lower Clearwater River during winter (reduced water quality in spawning areas). Reservoir operations at Dworshak Dam will continue to cool temperatures in the lower Clearwater River and lower Snake River reservoirs during summer (maintaining improved water quality in rearing areas). The proposed changes to reservoir operations at Dworshak Dam will not affect the functioning of water quantity in the spawning and rearing areas. The operation of mainstem reservoirs will continue to alter food webs and predator/prey interactions (reduced food, safe passage in rearing areas).
Adult and juvenile migration corridors	*Effects on migration corridor PBFs apply to the single extant population of SR fall Chinook salmon.* Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. The proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not affect the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal temperature regime in the Snake and Columbia Rivers due to thermal inertia associated with CRS reservoirs. Generally

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	cooler temperatures in the spring and warmer temperatures in late summer and fall. This will continue to adversely affect water quality in the juvenile migration corridor for the latest migrating subyearlings and in the adult migration corridor for the earliest migrating adults. The continued release of cold water from Dworshak Dam and operating the fishway cooling pumps at Little Goose and Lower Granite Dams will reduce migration delays for early migrating SR fall Chinook salmon (improved water quality and safe passage). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume, which may reduce “cover/shelter” in the migration corridor. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill at the CRS run-of-river projects in the lower Snake and Columbia Rivers. The effect on water quality in terms of the risk of GBT for spring-migrating juveniles is likely to be very small. The Corps will continue to protect water quality by using best management practices to minimize accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. The flexible spring spill operation to 125 percent TDG will increase safe passage for early migrating juveniles by increasing the likelihood of spillway passage. However, increased spill levels are likely to degrade tailrace conditions at Lower Granite, Little Goose, Lower Monumental, and John Day Dams (safe passage in the migration corridor), increasing the risk of bird and fish predation. Adults enter the lower Columbia River after the spring spill season and will not be exposed to increased risk of fallback from higher spill levels. Reduced summer spill at the eight mainstem dams during late August will improve adult ladder attraction conditions, but small numbers of adults that ascend the ladders will fall back through the turbines (small reduction in safe passage). Very small numbers of juvenile migrants that have not yet migrated through the hydrosystem will pass downstream through turbines (very small reduction in safe passage). Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (increase in safe passage). However, by increasing powerhouse flows, it will decrease safe passage for juveniles and adults by a small amount because some will pass downstream or fall back through a turbine unit. Increased operating range for John Day Reservoir will reduce the risk of avian predation while the increasing travel times of spring migrating juveniles by a small amount (small reduction in predation and slight decrease in safe passage). Continued implementation of the Action Agencies’ bird, fish, and pinniped predator management programs will continue recent levels of predation in the juvenile and adult migration corridors.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	The potential cessation of power generation at Snake River projects between 2300 and 0500 hours, October 15 to February 28, is likely to create a very small decrease in safe passage for the small numbers of adult SR fall Chinook salmon that are in the mainstem during this period. Though some overwintering SR fall Chinook salmon juveniles will be present, the quality of their rearing habitat or safe passage should not be measurably affected. Continued small increases in obstructions for adult fall Chinook salmon during routine outages of fishways or turbine units. Very small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities (e.g., to upgrade turbines at Ice Harbor, McNary, and John Day Dams and for a major repair such as the jetty and retaining wall at Little Goose Dam). Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Long-term effect of turbine upgrades will be reduced obstructions (improved turbine survival). Repairing the jetty at Little Goose Dam will also reduce obstructions for adults at that project. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Continued implementation of the Action Agencies' bird, fish, and pinniped predator management programs will continue recent levels of predation risk in the juvenile and adult migration corridors. Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels. This will increase access to prey, for yearling and large subyearling SR fall Chinook salmon that migrate in the mainstem channel without entering floodplain sites. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.5.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.2.1), Environmental Baseline (Section 2.2.2), and Effects of the Action (Section 2.2.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat, including for SR fall Chinook salmon.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on the population and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.5.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5.3) to the environmental baseline (Section 2.5.2) and the cumulative effects (Section 2.5.4), taking into account the status of the species and critical habitat (Section 2.5.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.5.5.1 Species

The SR fall Chinook salmon ESU comprises one MPG with one extant population inhabiting a large, geographically complex area with five major spawning groups: 1) Upper Hells Canyon, 2) Lower Hells Canyon, 3) Clearwater River, 4) Grande Ronde River, and 5) Tucannon River. Another large population spawned in areas upstream of Hells Canyon Dam, but was extirpated in the 1960s. Unlike SR spring/summer Chinook populations, fall Chinook spawn and rear in mainstem reaches of the Snake River and in the lower mainstem segments of its major tributaries. The recovery plan (NMFS 2017h) identified many limiting factors: blocked habitat (to areas upstream of Hells Canyon Dam), hydropower operations affecting the mainstem Snake and lower Columbia rivers, tributary habitat, estuary habitat, harvest, hatcheries, and predation.

The most recent status review (NMFS 2016b) rated SR fall Chinook salmon as viable (i.e., at low risk of extinction), an improvement over the moderate risk rating in the previous status review. This risk rating was based on a low risk rating for abundance/productivity and a moderate risk rating for spatial structure/diversity (NWFSC 2015). The geometric mean abundance estimates were exceeding recovery plan requirements, but considerable uncertainty existed relating to productivity, reflecting uncertainty due to the high numbers of hatchery-origin fish on the spawning grounds and whether recent (at that time) high escapements could be sustained over many years. Changes in major life history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity in samples from natural-origin returns, the high numbers of hatchery origin spawners, and the potential for selective pressure imposed by current hydropower operations and cumulative harvest impacts informed the moderate risk rating for spatial structure/diversity (NWFSC 2015).

Recent (2009 to 2013 and 2014 to 2018) 5-year rolling geometric means of natural origin spawning abundance have averaged over 8,800 adults, including returns since 2015 affected by below-average ocean survival associated with a marine heatwave and its lingering effects. Some of these negative effects had subsided by spring 2018 and expectations for marine survival were mixed for 2019 outmigrants.

With the exception of the Tucannon River major spawning group, which must pass six mainstem dams, SR fall Chinook salmon must pass eight mainstem dams on the lower Snake and lower Columbia rivers to reach the ocean and return to their spawning grounds. Subyearling juveniles predominantly outmigrate in May and June in the lower Snake and lower Columbia Rivers. Because of the generally cooler spawning and rearing conditions in the Clearwater River, juveniles from this major spawning group predominantly over-summer either in the lower Clearwater River or in the lower Snake River reservoirs, and most of these fish migrate the following spring (March through May) as yearlings. Adults predominantly migrate upstream in the Columbia and Snake River from August through November and spawn from October through November. Conditions for SR fall Chinook salmon have generally improved in the mainstem Columbia River because of the installation and operation of surface passage routes, 24-hour spill, improved spill patterns, and improvements to the juvenile bypass systems at the mainstem dams. The average survival of hatchery-origin subyearling fall Chinook salmon migrating from Lower Granite to McNary Dams has improved from about 53 percent during 1992 to 2005 to 70 percent during 2008 to 2017. Improvements made to John Day, The Dalles, and Bonneville Dams have likely improved passage conditions and juvenile survival to a similar extent. In the past, too few fish were detected in lower reaches to make survival estimates to Bonneville Dam, however, Smith (2020) provided new estimates of survival of hatchery-origin subyearlings from Lower Granite Dam to Bonneville Dam, which averaged 50.0 percent for the past ten years (2010 to 2019) and 65.0 percent during 2018 to 2019.

The juvenile survival rates from Lower Granite Dam to McNary Dam include all sources of mortality, even those that are not caused by the past or proposed operation and maintenance of the CRS. For instance, regardless of the operational or configurational choices made for the hydrosystem, some predation and other natural mortality of juvenile SR fall Chinook salmon would occur during their migration. In addition, juvenile survival is influenced by past and present alterations of shoreline habitat, among other stressors, unrelated to the effects of operating the hydrosystem; many of those effects will continue into the future. We are unable to differentiate the proportion of the losses that result from the operation and maintenance of the mainstem dams rather than to the existence of the dams, but we know that the mortality attributable to operations and maintenance is less than the losses captured in the overall survival estimates. As discussed further below, some also hypothesize that passage through juvenile bypass systems and turbines causes latent mortality, which would not be captured in the direct survival estimates.

Juvenile Chinook salmon are transported from Lower Granite, Little Goose, and Lower Monumental dams. Assessing the benefits of transport is challenging because relatively few known natural origin juveniles are tagged each year and production fish from hatcheries, because of their relatively large size, likely are not good surrogates for natural origin juveniles. Smith et al. (2018) found that the SARs of transported surrogate fish tended to consistently exceed those of bypassed fish by the first or second week in July. Early in the season (May to early June), bypassed fish often had higher SARs than transported fish, and the two were roughly equal through the remainder of June and sometimes in early July. Thus, transport may be somewhat detrimental to early migrating SR fall Chinook smolts, though this is when it has been shown to be most beneficial for other species (i.e., SR spring-summer Chinook salmon and steelhead). The Action Agencies propose to end transport on June 20, when spring spill operations ends, and resume transport via truck on a date between July 1 and August 15, to be decided in discussions with regional co-managers. Transport will continue through September 30 at Lower Monumental Dam and October 31 at Lower Granite and Little Goose Dams. Eliminating transport for the entire period from June 21 until August 15 would be expected to have a slight negative effect as transport has generally been shown to be beneficial (higher SARs) in late July and early August. However, only a relatively small fraction of the entire ESU's juveniles would be affected because the vast majority migrate prior to July or after August, so the overall effect on the ESU would range from zero to a small, negative impact depending upon the date that is ultimately selected.

Adult survival rates (adjusted to account for reported harvest and typical straying rates), include "natural" mortality as well as any mortality associated with injuries incurred from predators. Adult survival rates for SR fall Chinook salmon are relatively high, averaging nearly 93 percent from Bonneville to McNary Dam and about 90 percent from Bonneville to Lower Granite Dam. Increased spill levels should have extremely minimal to no effect on adult SR fall Chinook because they typically do not begin migrating past Bonneville Dam until late July or August, well after June 20. A small increase in adult mortalities could occur as a result of adults ascending the ladders but then falling back through the turbines at Snake River dams in August when spill is reduced. However, these losses would not be expected to substantively affect survival rates. The continued use of Dworshak Dam to cool lower Snake River temperatures and the addition of devices to pump cooler water into the top of the adult fishways at Lower Granite and Little Goose Dams should not only maintain, but improve, adult passage conditions at the Snake River projects in the late summer. Also consistent with NMFS' recommendations in the 2016 Adult Sockeye Report (NMFS 2016a), the Corps has greatly expanded its temperature monitoring capabilities in the fishways of the mainstem Snake and Columbia River dams. Based on these improved data, specific ladders will be evaluated to determine if structures similar to those designed and installed at Lower Granite and Little Goose Dams might be effective at reducing temperature differentials within the fishways. NMFS expects that this process will likely maintain or improve adult passage conditions, if necessary, at some dams in the lower Columbia River.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Overall, scheduled maintenance activities are expected to continue to negatively affect small numbers of adult Snake River fall Chinook salmon annually. A few adults will die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. The majority of juveniles are not likely to be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled, however, low numbers of rearing or overwintering juveniles will be affected. Non-routine and unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during high June flows, but because they are sporadic in nature and coordinated through the inseason adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative spill or turbine unit priorities) will likely minimize these impacts.

The proposed spring spill levels would implement a program of voluntary fish passage spill with the highest spill volumes ever implemented. This will increase juvenile exposure to higher TDG levels during the spring; however, it is unlikely that spilling up to 125 percent TDG for 16 hours per day at mainstem dams[194] will result in any substantial, negative impacts to juvenile survival because there are sufficient data and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms). The effects of higher spill levels should be extremely minimal to no effect on adult SR fall Chinook salmon. The proposed 125 percent flexible spring spill operation could potentially improve direct juvenile survival rates through the four lower Snake and four lower Columbia river mainstem projects (with the possible exception of Bonneville Dam, where survival rates could potentially decrease slightly). The CSS model predicts substantial juvenile survival increases for Snake River spring-summer Chinook salmon, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillbays) will increase adult returns of the Snake River populations by about 35 percent. If these predictions are realized (and SR fall Chinook salmon are benefited in a similar fashion), it would represent a substantial near term improvement in productivity and abundance for SR fall Chinook salmon (see NMFS' Life-Cycle Modeling for SR spring/summer Chinook salmon) and, over time, would reduce the severity of expected declines in abundance and productivity caused by a warming climate and deteriorating ocean conditions.

The proposed action does not include tributary habitat actions that specifically target SR fall Chinook salmon. There is some potential that habitat improvement actions targeted at SR spring/summer Chinook salmon and steelhead spawning and rearing habitat could benefit habitat used by SR fall Chinook salmon in the lower reaches of the Tucannon, Grande Ronde, and Clearwater Rivers (three of the five major spawning groups). Those effects (e.g., reduced sediment, improved flows, etc.), however, would be small and not have substantial benefits to SR fall Chinook salmon. In addition, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of SR fall Chinook salmon in these tributaries.

[194] Except at John Day Dam, The Dalles, and Bonneville Dam, where proposed spill operations are limited to 120 percent TDG, 40 percent spill, and 150 kcfs, respectively.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving SR fall Chinook salmon abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity and life-history diversity) for this ESU. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan, the Double-crested Cormorant Management Plan, and the IAPMP, as well as hazing at the mainstem dams. For SR fall Chinook salmon, we expect that management of tern colonies throughout the basin is reducing mortality by a small amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Cormorant predation rates may actually be increasing if more birds move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that prey on yearling Chinook salmon are also present in the hydrosystem reach. Increasing the John Day reservoir elevation in the spring should control impacts from the Blalock Islands tern colony. The NPMP and dam angling program are expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested Cormorant Management Plan, these programs will maintain current (reduced) levels of predation, creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on SR fall Chinook salmon downstream of Bonneville Dam has increased in the last decade with recent increases in the abundance of Steller sea lion in the late summer and fall but hazing near ladder entrances in the fall in conjunction with the other pinniped management actions is expected to discourage predation and maintain or reduce the impact.

The largest harvest-related effects on SR fall Chinook salmon result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery, and estimates that reported harvest rates, resulting from the abundance based harvest management approach, should continue to average about 37 percent. Additional fisheries, targeting hatchery origin fish upstream of Lower Granite Dam have also been authorized, but are not expected to exceed the overall allowed exploitation rates of 30 to 41 percent. Together with ocean fisheries, which have also undergone formal ESA consultation, overall harvest of Snake River fall Chinook salmon typically ranges between 40 and 50 percent.

The past effect of artificial production programs has been to provide harvest opportunities and to increase the overall abundance of SR fall Chinook. Potential risks posed by these hatchery programs include competition and predation effects, disease effects, genetic effects, and broodstock collection and facility effects. Overall hatchery production levels are expected to continue, though some actions have been taken that should decrease effects of hatcheries (competition and predation effects, and potentially, disease effects) to SR fall Chinook smolts rearing in, or migrating through, the lower Columbia River and estuary. Importantly, beginning in 2019, hatchery releases were relocated from the upper Hells Canyon major spawning group into the Salmon River Basin. The intent of this change (recommended in the Snake River fall Chinook Recovery Plan), was to reduce the proportion of hatchery origin spawners in this major spawning group, to reduce genetic risk, but also to provide an opportunity to estimate the productivity of natural origin spawners in a major spawning group. Overall, many of the effects of hatchery programs (both positive and negative) are expected to continue, with some key improvements that will lessen their overall effect to the ESU.

As described in Section 2.5.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect SR fall Chinook salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of SR fall Chinook salmon as high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change. However, the severity of those changes would be reduced as a result of the proposed action.

Fall-migrating adults could potentially respond temporally to changing environmental conditions by migrating later in the fall. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or winter flood events), but these effects are likely to be substantially dampened because they spawn and incubate in the lower segments of larger rivers where they are less vulnerable to these events. Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in these rivers. Juveniles using an ocean-type, subyearling life history strategy could potentially respond temporally by migrating earlier in the spring, avoiding exposure to higher summer temperatures. Though the quality of information is mixed, sensitivity in the marine stage is certainly high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur.

NMFS' life-cycle modeling, which considered three potential levels of changing climate severity over the next 24 years, clearly indicates that climate change effects, especially those that may manifest in the ocean, pose a substantial threat as they can have severe, negative consequences to the overall productivity (and abundance) of all SR spring/summer Chinook salmon populations (see life-cycle modeling). Based on the modeling, we expect abundances over the next 24 years to decrease and extinction risk to increase. However, ocean-type Chinook salmon generally appear to be less affected by warming conditions than stream-type Chinook salmon. These climate change consequences are not caused by the proposed action, and elements of the proposed action (flexible spring spill operations, estuary habitat restoration and research, monitoring, and evaluation programs) should help to improve the resiliency of SR fall Chinook salmon populations to expected climate change effects. In simple terms, even if the adult abundance declines as predicted under climate change, which will make recovery of this ESU more challenging, it will have declined less as a result of the proposed action because in many ways the proposed action is expected to improve the functioning of VSP parameters and thus positively contribute to the survival and recovery of the species.

The proposed action—the future operation and maintenance of the CRS (including upper Columbia River operations to better protect resident species and Dworshak Dam winter operations to reduce TDG in the lower Clearwater River)—will have little overall effect on the seasonal hydrograph or seasonal temperatures compared to recent conditions. The seasonal hydrograph will continue to be altered, generally increasing flows in the fall and winter, and reducing flows in the spring. Seasonal water temperatures will also continue to be altered, with delayed warming in the spring, delayed cooling in the fall, and reduced daily temperature variability. These effects to river conditions likely adversely affect the survival of SR fall Chinook salmon, but to an extent not readily quantified based upon the best available information.

Other operations (e.g., operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, increasing the John Day reservoir operating range during the spring to reduce avian predation, etc.) are, collectively, expected to have a small, negative effects, especially on overwintering juveniles and little to no effect on adults (which typically migrate in August and September), but these effects should not measurably alter survival between Lower Granite and Bonneville Dam.

The proposed action includes many measures to reduce the adverse effects of the passage impediments caused by the existence of the CRS, including juvenile fish passage spill, operation of juvenile bypass systems, attraction flows for adults, and the operation of adult fish ladders. In addition to these measures, the proposed flexible spring spill operation is expected to improve juvenile survival through the mainstem migration corridor and if flexible spring spill operation increases adult returns by up to 35 percent as hypothesized by the CSS for SR spring/summer

Chinook salmon, a substantial near-term improvement in productivity and adult abundance over current conditions. Adaptively managing transport operations (using juvenile migration monitoring and seasonal patterns in adult returns to guide start and stop date decisions) will continue to improve adult returns (relative to bypassed fish).

Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this ESU (e.g., dam passage survival, population productivity, degraded estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.).

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity and likely affects marine survival (to an unknown extent) through latent mortality. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., estuary habitat, predation, etc.). Evidence shows that these actions have likely contributed to improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The recent downturn in adult abundance (2014 to 2019) is primarily the result of recent poor ocean conditions and not of altered tributary and mainstem habitat conditions. The proposed action carries forward structural and operational improvements since 2008 and improves upon them. Additional juvenile survival improvements are expected from the flexible spring spill operation and potential improvements resulting from reduced latent mortality are possible, and ecosystem functions should continue to increase in estuary habitats where improvement actions occur.

Climate change is a threat to SR fall Chinook salmon, especially during the marine rearing phase of their life cycle. The proposed action is expected to reduce both the scope and severity of those impacts and not exacerbate them. The proposed action therefore is expected to increase the resiliency of the populations to climate change and provide time for other recovery actions to be implemented.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of SR fall Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of SR fall Chinook salmon.

2.5.5.2 Critical Habitat

Designated critical habitat for SR fall Chinook salmon consists of all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to the Snake River confluence, as well as all river reaches of the mainstem Snake River upstream to Hells Canyon Dam, as well as all river reaches presently and historically accessible (except above Dworshak and Hells Canyon Dams). Across subbasins in the Interior Columbia Recovery Domain with PBFs for SR fall Chinook salmon, land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity. Past and current land use or water management activities have adversely affected the quality and quantity of riparian conditions and side channels, floodplain function, sediment conditions, and other water quality and quantity parameters. As a result, the important watershed processes and functions that once created healthy ecosystems for fall Chinook salmon production have been weakened. An important exception is that the stabilization of outflow at Idaho Power Company's Hells Canyon Dam has resulted in high-quality spawning and rearing habitat in the downstream reach of the lower Snake River, which supports the conservation of the remaining population. These outflows provide resiliency to climate-induced changes in temperature and flow. However, other water quality (low dissolved oxygen levels in the late summer and early fall, elevated TDG levels in winter and spring) and substrate problems (entrapment of sediment) remain.

The environmental baseline also includes a broad range of past and present actions and activities, including effects of the hydrosystem, that have affected the conservation value of critical habitat in freshwater migration corridors for SR fall Chinook salmon. Some of these past effects of CRS operations will continue under the proposed action: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and passage delays (safe passage in the juvenile migration corridor). These factors have increased the likelihood of excessive predation on juvenile and adult fall Chinook salmon and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The proposed action carries forward structural and operational improvements since 2008 that address these effects on PBFs and in some cases, improves upon them. The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. The Action Agencies will continue to use cold water from Dworshak Reservoir and the devices that provide cool water in the fish ladders and forebay exit areas at Little Goose and Lower Granite Dams to maintain safe passage for the earliest fall Chinook salmon migrants by preventing rejection of the ladder entrances and delay at the exits. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors.

The Action Agencies also have reduced effects of their operations on travel time and survival for yearling migrants, including many from the SR fall Chinook salmon ESU by increasing levels of spring spill. We expect the additional flexible spring spill to 125 percent TDG to reduce water quality in the juvenile migration corridor by a small amount for yearling fall Chinook migrants while having a small positive effect on safe passage at CRS projects in the lower Snake and Columbia Rivers through increased spillway passage. In low runoff years, increased spill could degrade tailrace conditions for juvenile migrants at Lower Granite, Little Goose, Lower Monumental, and John Day Dams, increasing the risk of bird and fish predation. However, there is sufficient flexibility through the in-season management process to identify and remedy negative effects through modified spill patterns. Water quality and safe passage in the adult migration corridor will not be affected by the increased spill because SR fall Chinook migrate after the spring spill period ends on June 20.

Operating turbines above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve attraction for adults (increase in safe passage). However, by increasing powerhouse flows, it will decrease safe passage by a small amount because some adults will fall back or juveniles will move downstream through turbines.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors.

In summary, the proposed action is not likely to further limit water quantity or water quality or to reduce safe passage in the juvenile or adult migration corridors by a meaningful amount. In addition, if the CSS hypothesis regarding latent mortality is correct, the flexible spill program could improve the functioning of the juvenile migration corridor to a much greater extent than indicated by the likely effects on safe passage described above.

Increasing the elevation of John Day Reservoir to cover nesting areas on the Blalock Islands will limit the risk of predation by Caspian terns by delaying nesting until about 95 percent of spring outmigrants have passed McNary Dam, which will also protect yearling SR fall Chinook salmon migrants. The Action Agencies also will continue to implement measures to reduce pinniped predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the hydrosystem and the estuary, and the predation management programs for Caspian terns on the interior plateau and for terns and double-crested cormorants on East Sand Island in the estuary. We expect that these actions will maintain the levels of predation within the juvenile and adult migration corridors that were achieved in recent years, although cormorant predation rates may increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. The Action Agencies' proposed estuary habitat program will continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling and subyearling SR fall Chinook salmon migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of SR fall Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of SR fall Chinook salmon designated critical habitat.

2.5.6 Conclusion

After reviewing and analyzing the current status of SR fall Chinook salmon and critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SR fall Chinook salmon or destroy or adversely modify its designated critical habitat.

2.6 Upper Columbia River (UCR) Spring-run Chinook Salmon

This section applies the analytical framework described in Section 2.1 to the UCR spring-run Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the UCR spring-run Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.6.1 Rangewide Status of the Species and Critical Habitat

The status of the UCR spring-run Chinook salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.6.1.1 Status of the Species

2.6.1.1.1 Background

On March 24, 1999, NMFS listed the UCR spring-run Chinook salmon ESU as endangered under the ESA (64 FR 14308), and the status was reaffirmed on June 28, 2005 (70 FR 37160). Critical habitat for the ESU was designated on September 2, 2005 (70 FR 52630). The most recent status review, in 2016, concluded that the ESU should retain its endangered status (81 FR 33468). The summary that follows describes the rangewide status of UCR spring-run Chinook salmon. More information can be found in the recovery plan (UCSRB 2007) and most recent status review for this species (NMFS 2016d).[195]

The UCR spring-run Chinook salmon ESU includes all naturally spawned spring-run Chinook salmon originating from Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam (excluding the Okanogan River). The ESU comprises three extant independent populations, which are grouped into one MPG (historically, a population also spawned in the Okanogan and would also have been part of this MPG, but it is extirpated and not required to achieve the ESA recovery goals).[196] It also includes spring-run Chinook salmon from

[195] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

[196] On July 11, 2014, NMFS designated the Okanogan River population as a "nonessential experimental population" of UCR spring-run Chinook salmon (79 FR 40004).

six artificial propagation programs (Table 2.6-1) (70 FR 37160).197 Historically, UCR spring-run Chinook salmon likely included two additional MPGs (Figure 2.6-1). These were extirpated by the completion of Grand Coulee and Chief Joseph Dams, and reintroduction of these extirpated MPGs is not required for recovery as defined in the ESA recovery plan (UCSRB 2007).

Table 2.6-1. UCR spring-run Chinook salmon major population group and component populations, and hatchery programs (UCSRB 2007, 70 FR 37160).

Major Population Group	***Populations***
North Cascades MPG	Wenatchee River Entiat River Methow River
Hatchery Programs	
Hatchery programs included in ESU	Twisp River Methow River Winthrop National Fish Hatchery Chiwawa River White River Chewuch River

[197] For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including UCR spring-run Chinook (81 FR 72759). The proposed changes for hatchery program inclusion in this ESU were to add the Nason Creek Program and the Chief Joseph spring Chinook Hatchery Program and remove the Chewuch River Program (as it is considered to be part of the Methow Composite Program). We expect to publish the final revisions in 2020.

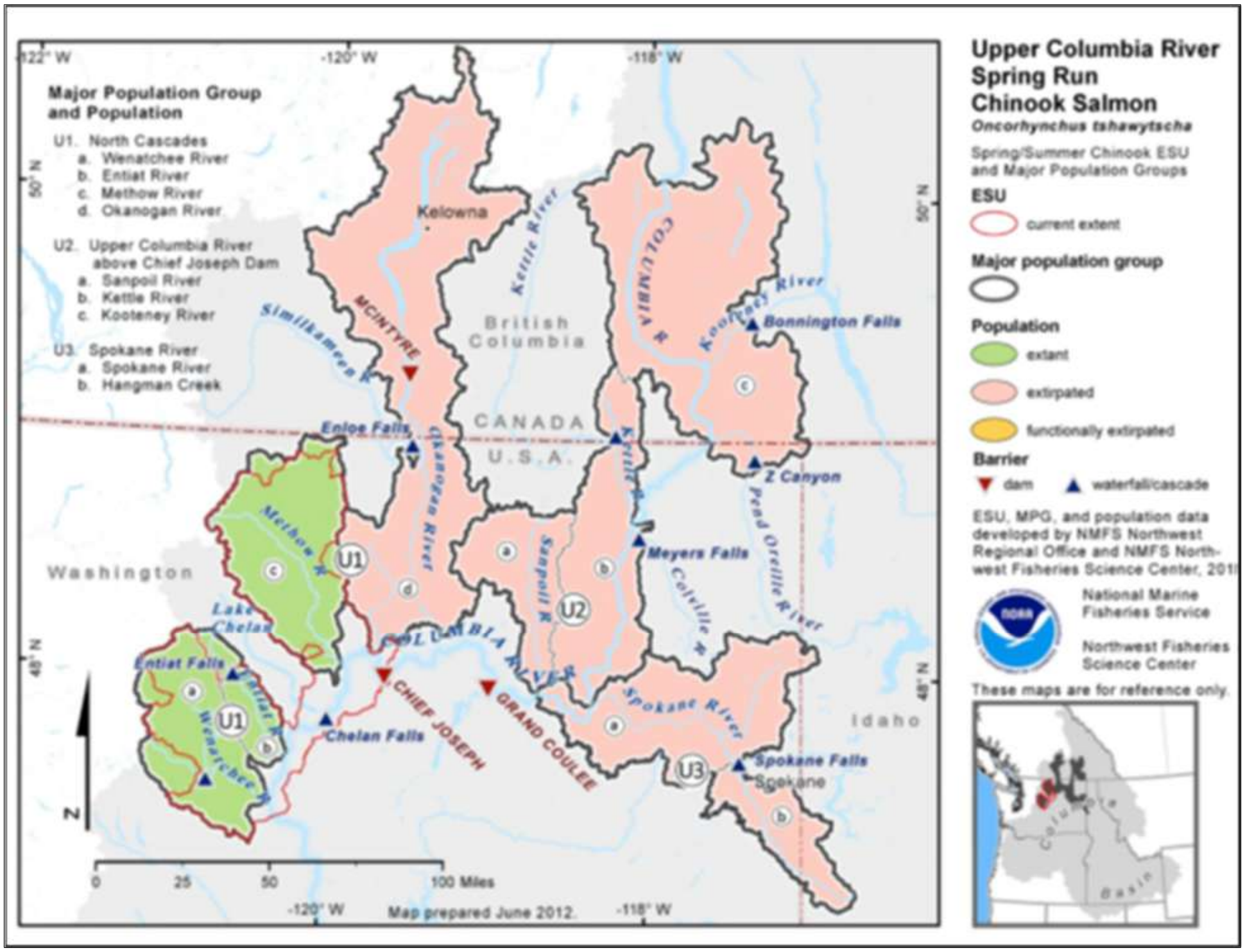

Figure 2.6-1. Map illustrating UCR spring-run Chinook salmon ESU's populations and major population groups (NWFSC 2015).

2.6.1.1.2 Life History and Factors for Decline

Adult UCR spring-run Chinook salmon begin returning from the ocean in April and May, with the run into the Columbia River peaking in mid-May. They enter the upper Columbia River tributaries from April through July. After migration, they hold in freshwater tributaries until spawning occurs in the late summer, peaking in mid-to-late August. Juvenile spring Chinook salmon spend a year in freshwater before migrating to saltwater in the spring of their second year of life. Most UCR spring-run Chinook salmon return as adults after 2 or 3 years in the ocean. Some precocious males, or jacks, return after one winter at sea. A few other males mature sexually in freshwater without migrating to the sea. The run, however, is dominated by 4- and 5-year-old fish that have spent 2 and 3 years at sea, respectively. Fecundity ranges from 4,200 to 5,900 eggs, depending on the age and size of the female (UCSRB 2007).

Factors contributing to the decline of UCR spring-run Chinook salmon included the intensive commercial fisheries in the lower Columbia River. These fisheries began in the latter half of the 1800s, continued into the 1900s, and nearly eliminated many salmon and steelhead stocks. With time, the construction of dams and diversions, some without passage, blocked or impeded salmon and steelhead migrations. Early hatcheries, operated to mitigate the impacts of dams on fish passage and spawning and rearing habitat, employed practices such as transferring fish among basins without regard to their origin. While these practices increased the abundance of stocks, they also decreased the diversity and productivity of populations they intended to supplement. Concurrent with these activities, human population growth within the basin was increasing and land uses were adversely affecting salmon spawning and rearing habitat. In addition, non-native species were introduced by both public and private interests that directly or indirectly affected salmon (UCSRB 2007).

Annual spawning escapements for all three of the extant UCR spring-run Chinook salmon populations showed steep declines beginning in the late 1980s, leading to extremely low abundance levels in the mid-1990s.

All three extant populations spawn in tributaries to the Columbia River upstream of the confluence of the Snake River with the Columbia River. They pass the four lower Columbia River dams (Bonneville, The Dalles, John Day, and McNary), operation of which is part of the proposed action. In addition, all three populations also spawn upstream of the PUD-operated Priest Rapids, Wanapum, and Rock Island Dams on the upper Columbia River. The Entiat River population must pass one additional PUD dam (Rocky Reach) and the Methow population must pass two additional PUD dams (Rocky Reach and Wells Dams). The operation of these PUD dams is not part of the proposed action.

2.6.1.1.3 Recovery Plan

The ESA recovery plan for UCR spring-run Chinook salmon (UCSRB 2007) includes delisting criteria for the ESU, along with identification of factors currently limiting its recovery, and management actions necessary to achieve the goals.[198] The biological delisting criteria are based on recommendations by the ICTRT.[199] They are hierarchical in nature, with ESU-level criteria based on the status of natural-origin UCR spring-run Chinook salmon assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the ESU will require improvement in the abundance, productivity, spatial structure, and diversity of all three extant populations to the point that all three are considered viable (i.e., at low risk of extinction) (UCSRB 2007).

2.6.1.1.4 Abundance, Productivity, Spatial Structure and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within the ESU based on parameters of abundance, productivity, spatial structure, and diversity (these

[198] This plan was developed by the Upper Columbia Salmon Recovery Board and then reviewed and adopted by NMFS (72 FR 57303).

[199] The recovery plan also includes “threats criteria” for each of the relevant listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the ICTRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low risk. Generally, each MPG must achieve low risk for the ESU as a whole to be considered no longer threatened or endangered. For the single UCR spring-run Chinook salmon MPG to achieve low risk, all three of its extant populations must achieve viable status (i.e., low extinction risk) (UCSRB 2007).

As of the most recent status review (NMFS 2016d), the 5-year geometric mean abundance of adult natural-origin spawners had increased for each population relative to the levels reported in the 2011 status review, but natural-origin escapements remained well below the corresponding ICTRT thresholds for viability (i.e., low extinction risk). The short-term (e.g., 15-year) trend in natural-origin spawners was neutral for the Wenatchee River population and positive for the Entiat and Methow River populations. Time series of smolt production data from several locations within the Wenatchee subbasin showed some indication of density-dependent effects at higher spawning levels. The evaluation of overall abundance and productivity resulted in all three extant populations continuing to be rated at high risk (NWFSC 2015, NMFS 2016d).

In the most recent status review (NMFS 2016d), all three populations continued to be rated at low risk for spatial structure and at high risk for diversity. The high risk diversity rating was driven primarily by continued high proportions of hatchery-origin spawners in natural spawning areas and a lack of genetic diversity among the natural-origin spawners. Direct hatchery supplementation in the Entiat subbasin was discontinued in 2007, and an upward trend in the proportion of natural-origin spawners in that population was attributed to that closure. Large-scale hatchery supplementation programs continued in the Methow and Wenatchee Rivers. These programs are intended to counter short-term demographic risks given current average survival levels and the associated year-to-year variability. The composite spatial structure/diversity risks for all three of the extant natural populations in this ESU were also rated as high (NWFSC 2015, NMFS 2016d).

Table 2.6-2 lists the MPGs and populations in this ESU and summarizes their abundance/productivity, spatial structure, diversity, and overall population risk status, based on information in the most recent status review (NWFSC 2015, NMFS 2016d); it also summarizes their target risk status for delisting (UCSRB 2007).

Table 2.6-2. UCR spring-run Chinook salmon population-level risk for abundance/productivity (A/P), diversity, integrated spatial structure/diversity (SS/D), overall status as of the most recent status review (NWFSC 2015, NMFS 2016d), and recovery plan target status (UCSRB 2007). Risk ratings range from very low (VL) to low (L), moderate (M), high (H), very high (VH), and extirpated (E).

Population	ICTRT Minimum Abundance Threshold[1]	A/P Risk Rating	Diversity Risk Rating	Integrated SS/D Risk Rating	Overall Extinction Risk	Recovery Plan Target Extinction Risk Rating
Wenatchee River	2,000	H	H	H	H	L
Entiat River	500	H	H	H	H	L
Methow River	2,000	H	H	H	H	L

[1]Minimum abundance thresholds represent the number of spawners needed for a population of a given size category to achieve low risk (viability) at a given productivity (ICTRT 2007).

2.6.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect UCR spring-run Chinook salmon provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. Limiting factors identified in the recovery plan (UCSRB 2007) for this ESU include (in no particular order):

- Habitat degradation: Human activities have altered and/or curtailed habitat-forming processes and limited the habitat suitable for UCR spring-run Chinook salmon in the upper Columbia River tributaries. Storage dams, diversions, roads and railways, agriculture, residential development, and forest management continue to cause changes in water flow, water temperature, sedimentation, floodplain dynamics, riparian function, and other aspects of the ecosystem, that are deleterious to UCR spring-run Chinook salmon and their habitat.
- Hydropower systems: Conditions for UCR spring-run Chinook salmon have been fundamentally altered by the construction and operation of mainstem dams for power generation, navigation, and flood control. UCR spring-run Chinook salmon are adversely affected by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage, and ecological changes caused by impoundments. Effects occur at the four Federal dams on the lower Columbia River and at FERC-licensed dams on the Upper Columbia River.[200]

[200] All three populations spawn upstream of the PUD-operated Priest Rapids, Wanapum, and Rock Island Dams on the upper Columbia River. The Entiat River population must pass one additional PUD dam (Rocky Reach) and the Methow population must pass two additional PUD dams (Rocky Reach and Wells Dams).

- Harvest: Historical harvest rates have been reduced from their peak as a result of international treaties, fisheries conservation acts, the advent of weak-stock management, regional conservation goals, and the ESA listing of many salmon ESUs and steelhead DPSs. While fisheries do not target weak stocks of listed salmon or steelhead, listed fish are incidentally caught in fisheries directed at hatchery and unlisted natural-origin stocks.
- Hatcheries: In the upper Columbia River region, hatcheries producing spring-run Chinook salmon are operated to mitigate the impacts of habitat loss resulting from the construction of Grand Coulee Dam and passage and habitat impacts of the mid-Columbia PUD dams. While these hatcheries provide valuable mitigation and/or conservation benefits, they can also cause adverse impacts, including genetic effects that reduce fitness and survival, ecological effects such as competition and predation, facility effects on passage and water quality, incidental handling and mortality due to harvest, and masking of the true status of natural-origin populations.
- Additional factors include changes in estuarine habitat, climate change, inadequacy of regulatory mechanisms, fluctuating ocean cycles, and predation.

In its most recent status review NMFS (2016d) noted that:

- Despite efforts to improve tributary habitat conditions, considerable improvement is still needed to restore habitat to levels that will support viable populations.
- Direct survival of juvenile salmonids outmigrating from upper Columbia River populations has increased as a result of juvenile passage improvements at Federal and PUD dams.
- Harvest exploitation rates[201] have remained relatively low, generally below 10 percent, though they had been increasing in recent years. The recent increases have resulted from increased allowable harvest rates under the abundance-driven sliding-scale harvest rate strategy that guides annual management.
- Natural-origin contributions to spawning in the Wenatchee and Methow River populations have trended downwards since 1990. NMFS (2016d) said that this reflected increased hatchery supplementation in those populations to boost abundance. Spring-run Chinook salmon hatchery releases into the Entiat River were discontinued in 2007, and the numbers of hatchery-origin spawners have decreased in response.
- Avian and pinniped predation on UCR spring-run Chinook salmon have increased since the previous status review in 2011, and non-indigenous fish species remain a threat.
- Some regulatory mechanisms have improved since the previous status review, but, particularly for land-use regulatory mechanisms, there was lack of documentation or analysis of their effectiveness.

[201] Exploitation rate is the proportion of the total number of fish from a given natural-origin population(s) or hatchery stock(s) that die from the result of fishing activity in a given year.

- Climate change was a concern, particularly the future effects of continued warming in marine and freshwater systems.

2.6.1.1.6 Information on Status of the Species since the 2016 Status Review

The best scientific and commercial data available with respect to the adult abundance of UCR spring-run Chinook salmon indicates a substantial downward trend in the abundance of natural-origin spawners at the ESU level from 2015 to 2019 (Figure 2.6-2). This recent downturn is thought to be driven primarily by marine environmental conditions and a decline in ocean productivity (see discussion below) because hydropower operations, the overall availability and quality of tributary and estuary habitat, and hatchery practices have been relatively constant or improving over the past 10 years.[202] Increased abundance of sea lions in the lower Columbia River could also be a contributing factor.

Population-level abundance estimates of natural-origin and total (natural- plus hatchery-origin) spawners through 2018 are shown in Table 2.6-3. These data also show recent and substantial downward trends in abundance for all three populations of UCR spring-run Chinook salmon when compared to the 2009 to 2013 period.[203] All populations remain considerably below the minimum abundance thresholds established by the ICTRT (shown in Table 2.6-2) and include substantial numbers of hatchery-origin adults.

[202] Many factors (e.g., higher summer temperatures, lower late summer flows, low spring flows, etc.) affect the ability of tributary habitat to produce juvenile migrants (capacity) each year. Recent drought and temperature patterns may have had a negative effect on tributary habitat productivity, and as a result, lower than average juvenile production may have contributed in some years to downturns in adult abundance.

[203] The upcoming status review, expected in 2021, will include population-level adult returns through 2019, and will add a new rolling 5-year geomean, for 2015 to 2019. Because the 2015 adult returns represented a peak at the ESU level (Figure 2.6-2), the negative percent change between the 2015–2019 and 2014–2018 geomeans will not necessarily be greater than that shown in Table 2.6-3 between the 2014–2018 and 2009–2013 geomeans, at least for some populations.

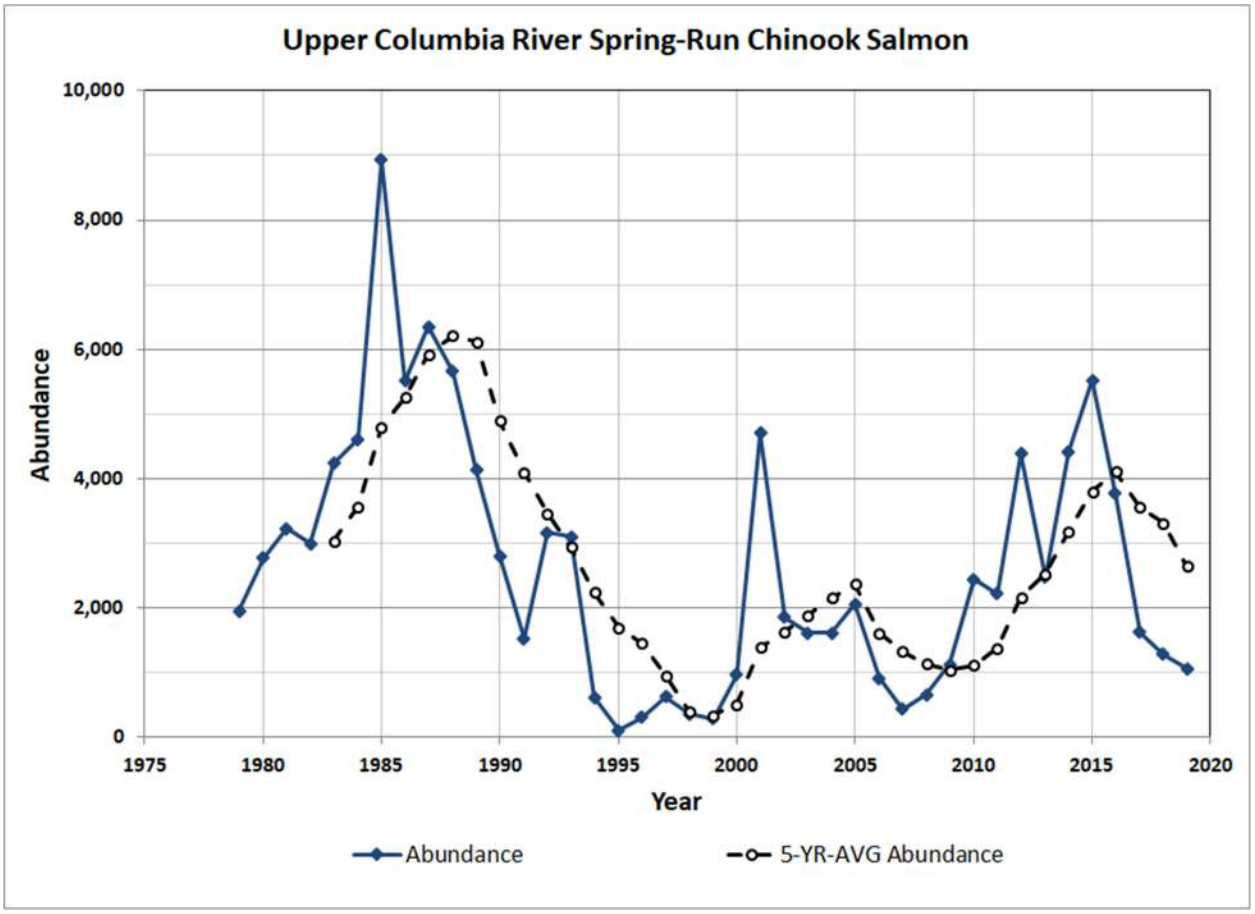

Figure 2.6-2. Annual abundance and 5-year average abundance estimates for the UCR spring-run Chinook salmon ESU (natural-origin fish only) at Rock Island Dam based on passage counts from 1979 to 2019. Data are from the 2020 Joint Staff Report on Stock Status and Fisheries (ODFW and WDFW 2020).

Table 2.6-3. 5-year geometric mean of natural-origin spawner counts for UCR spring-run Chinook salmon, excluding jacks. Number in parenthesis is the 5-year geometric mean of total spawner counts. "% change" is a comparison between the two most recent 5-year periods (2014-2018 compared to 2009-2013). "NA" means not available. At the time of drafting this opinion, 2019 data were not available for any of the populations in this ESU. Source: (Williams 2020d).

MPG	Population	1989–1993	1994–1998	1999–2003	2004–2008	2009–2013	2014–2018	% Change
North Cascades	Entiat River	NA	44 (55)	104 (190)	121 (284)	228 (336)	134 (186)	-41 (-45)
	Methow River	NA	60 (89)	159 (1158)	351 (1256)	428 (1785)	295 (803)	-31 (-55)
	Wenatchee River	NA	102 (208)	423 (971)	371 (1372)	664 (1987)	517 (1230)	-22 (-38)

NMFS will evaluate the implications for viability risk of these more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.6-3.

Since 2016, observations of coastal ocean conditions indicate that recent outmigrant year classes have experienced below average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict the drop in adult returns observed through 2019 (Werner et al. 2017). Some of the negative impacts on juvenile salmonids had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 50-meter surface layer) had not returned to normal (Harvey et al. 2019). Expectations for marine survival are relatively mixed for juvenile Chinook salmon that reached the ocean in 2019 (Zabel et al. 2020). Based on mainstem dam counts, overall returns of spring Chinook salmon in 2020 also appear to be low, similar to 2019 counts.

2.6.1.2 Status of Critical Habitat

NMFS designated critical habitat for UCR spring-run Chinook salmon to include all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to its confluence with the Methow River (50 CFR 226.212(j)). All mainstem river reaches, including those in the Columbia River estuary, were given high ratings. Of 32 designated HUC5[204] watersheds in the Columbia River and the Methow, Entiat, Wenatchee subbasins, NMFS (2005b) gave 27 a high rating and five a medium rating for their value to the conservation (i.e., recovery) of the species.

The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features, NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b), as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.

[204] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watershed throughout the country. A HUC is a five-unit (5 two-digit numbers) code. Examples are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the Wenatchee River basin, Washington.

- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.
- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.
- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case with freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The complex life cycle of UCR spring-run Chinook salmon gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas, and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead rely on limited energy stores to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005b). In the following paragraphs, we discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary Recovery Domains.

2.6.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia Recovery Domain for UCR spring-run Chinook salmon. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Critical habitat throughout much of the Interior Columbia Recovery Domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas. Restoration activities addressing tributary habitat quality and complexity, tributary and mainstem migration barriers, water quality, and excessive predation have improved the baseline condition for PBFs in some locations.

UCR spring-run Chinook salmon have lost access to large blocks of their historical habitat. The construction of Chief Joseph and Grand Coulee Dams blocked fish access to historical habitat in the upper Columbia River and its major tributaries. Many smaller dams, and some temporary dams, were also built on tributaries at this time without fish passage facilities and had the same effects, though on much smaller scales. The loss of this historical habitat significantly reduced the spatial structure that was once available to the species.

Construction of other large hydropower and water storage projects associated with the CRS further affected salmonid migratory conditions and survival rates. As noted above, the production of UCR spring Chinook salmon was especially impacted by the development of the four major Federal dams and reservoirs in the mainstem lower Columbia River and five PUD-owned dams in the middle Columbia River migration corridor. Hydrosystem development also modified natural flow regimes, resulting in warmer late summer and fall water temperatures. Changes in fish communities led to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids.

Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams such as turbines and juvenile bypass systems have also killed some outmigrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented improvements in the juvenile and adult migration corridors, including 24-hour volitional spill, improved surface passage routes, improved juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

Many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain are over-allocated, with more allocated water rights than existing stream flow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a limiting factor for UCR spring-run Chinook salmon (UCSRB 2007).

Many stream reaches designated as critical habitat are listed on the Oregon and Washington Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures (Spence et al. 1996). Furthermore, contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste are common in some areas of critical habitat. They can negatively impact critical habitat and the organisms associated with these areas.

2.6.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat also has been designated for UCR spring-run Chinook salmon in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained the dynamic environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels; marsh and riparian habitats have been filled and diked; and causeways have been constructed that restrict the position of tributary confluences.

Over time, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of the historical variability in mainstem flows in the lower river through storage and release operations at upstream reservoirs may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has reduced the delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The combined effect of these changes is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs, and thus the conservation value of critical habitat for UCR spring-run Chinook salmon, within the action area are discussed in more detail in the Environmental Baseline section, below.

2.6.1.3 Climate Change Implications for UCR Spring-run Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of UCR spring-run Chinook salmon and aquatic habitat is climate change. The USGCRP[205] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[206] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.

[205] http://www.globalchange.gov

[206] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, earlier emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003, Crozier et al. 2008a, Martins et al. 2012, Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy among interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- Direct effects of increased water temperatures on fish physiology.
- Temperature-induced changes to stream-flow patterns, which can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.
- Alterations to freshwater, estuarine, and marine food webs that alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity that affect the abundance and productivity of fish resources.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change and the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Crozier et al. (2019) assessed UCR spring-run Chinook salmon as having high vulnerability to the effects of climate change based on an analysis of the ESU's sensitivity (high), exposure (high), and adaptive capacity (moderate).[207] The high overall sensitivity scores stemmed largely from migration characteristics. Multiple studies have examined the effect of climate change on water temperature and potential viability of populations in this ESU (Cristea and Burges 2010, Honea et al. 2016). Adult holding occurs in some lower tributaries where it is associated with high pre-spawn mortality. However, it appears to be mainly hatchery production fish that utilize these lower-river holding areas. Thus, natural-origin stocks do not appear directly threatened by high stream temperatures in holding tributaries.

Increasing fine sediment due to increased winter flooding has been highlighted as a potential risk (Honea et al. 2016), although it was considered a lower risk for this ESU than for other Chinook salmon ESUs. UCR spring-run Chinook was ranked very high in sensitivity for the adult freshwater stage and very high in exposure to hydrologic regime shift. Most of this ESU inhabits streams with temperatures that are currently below optimal for growth, so short-term warming does not pose an imminent threat to juvenile survival. Nonetheless, juveniles in this ESU characteristically spend a full year in freshwater, and smolt survival depends on high spring flows, so the ESU was ranked very high in sensitivity to climate change at the juvenile freshwater stage.

Long migrations contribute to climate risk for populations in this ESU; however, their spawning and rearing habitat is of relatively high quality compared to those of many other ESUs. Eggs incubate over winter, with relatively low risk of warming, and this was reflected in a low mean sensitivity attribute score. Flow regime in the Columbia River basin is strongly driven by snowmelt; therefore, loss of snowpack and subsequent reduction in the spring freshet will affect juvenile rearing and smolt migration. Although the spring smolt migration is slower in low snowpack years, earlier migration timing might benefit this ESU because at present, much of the population enters the ocean later than the optimal period for survival (Scheuerell et al. 2009). This was reflected in a moderate rank for the marine stage. The longer juvenile residence period translates to a higher risk of freshwater mortality but allows smolts to spend very little time in the estuary and lowers exposure to sea level rise. Thus, UCR spring-run Chinook ranked low in sensitivity at the estuary stage.

The primary concern in terms of cumulative life-cycle effects is loss of the unique life histories of spring-run adults and yearling juvenile migrants. Cumulative life-cycle effects were ranked moderate. However, UCR spring-run Chinook are at less risk than SR spring/summer Chinook salmon, largely because of cooler temperatures in rearing and in most natural-spawner holding habitat and earlier adult migration, which largely avoids high temperature stress during migration, prespawn holding, and juvenile rearing.

[207] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results

In terms of interaction with extrinsic factors, most populations are at high risk of extinction due to low abundance and productivity. Spatial structure is also greatly depleted in this ESU because much of its original spawning habitat is blocked by impassable dams. Sensitivity to population viability was therefore ranked very high. This ESU also ranked high in sensitivity to hatchery influence because it is heavily supplemented by hatcheries, and natural reproduction is low. Its location in an agricultural region contributed to a high rank for other stressors, particularly water diversions and habitat loss.

UCR spring-run Chinook salmon may have sufficient adaptive capacity to shorten the juvenile freshwater residence period, but the consequences of such a shift for population viability are unknown. This ESU was deemed unlikely to shift upstream migration timing substantially. Overall, the ESU was ranked moderate in adaptive capacity.

2.6.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima are likely to be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce fitness for salmonids, including UCR spring-run Chinook (Beechie et al. 2013, Wainwright and Weitkamp 2013, Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a, Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are others where it is detrimental (Sykes et al. 2009, Whitney et al. 2016).

2.6.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snowpack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location (Crozier et al. 2008b, Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b, Beechie et al. 2013). However, river flow is already becoming more variable in many rivers and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely that this increasingly variable flow is detrimental to multiple salmon and steelhead populations in the Columbia River basin.

The effects of climate change on stream ecosystems are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes are likely to lead to shifts in the distributions of native species and facilitate establishment of exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016, Rehage and Blanchard 2016). How juvenile native species will fare as part of “hybrid food webs,” which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.6.1.3.3 Estuarine Effects

In estuarine environments, the two greatest concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013, Limburg et al. 2016). Estuaries will be affected directly by sea-level rise; as sea levels rise, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010, Wainwright and Weitkamp 2013, Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006, Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict inward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species and life history types are highly reliant on estuarine wetlands for rearing, many populations use them extensively (Jones et al. 2014). Others, such as yearling UCR spring-run Chinook salmon benefit from the influx of prey from the floodplain to the mainstem migration corridor (Johnson et al. 2018, PNNL and NMFS 2018, 2020).

2.6.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010, Asch 2015, Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years. For example, range extensions were documented in many species from southern California to Alaska during unusually warm water associated with the marine heatwave known as “the blob” in 2014 and 2015 (Bond et al. 2015, Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002, Fisher et al. 2015). The frequency of extreme conditions such as those associated with marine heatwaves or El Niño events is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015, Rehage and Blanchard 2016). While it is certain that these effects will occur, current models cannot predict the composition or outcomes of future trophic interactions. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm ocean conditions, suggesting that, at a minimum, prey availability and prey quality, "bottom-up" drivers of growth and survival, may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem[208] (Bograd et al. 2009, Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014, Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unaffected by climate change, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean (Tomaro et al. 2012), and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007, Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in Alaska salmon productivity and survival (Mantua et al. 1997, Martins et al. 2012). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009, Martins et al. 2012). However, more recent information indicates that Alaska salmon, which have historically contrasted with southern populations by benefitting from warm phases of the PDO, no longer have a positive correlation with winter sea-surface temperature (Litzow et al. 2018) and are more synchronized with southern populations (Ohlberger et al. 2016). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

[208] The California Current moves southward along the western coast of North America, beginning off southern British Columbia and ending off the southern Baja California Peninsula.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon is likely to be its influence on marine food webs, especially at the lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015, Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.6.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change in general, including in the Pacific Northwest. The indirect effects of climate change are also uncertain, including whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013, Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will involve impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning that some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is less certain, leading to a range of potential future outcomes.

2.6.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or

designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For UCR spring-run Chinook salmon, we focus our description of the environmental baseline on where UCR spring-run Chinook salmon juveniles and adults are most exposed to the effects of the proposed action, including tributary habitats where the Action Agencies propose to implement habitat restoration actions.

To determine the upstream extent of UCR spring-run Chinook salmon distribution and thus most exposure to the effects of the proposed action, we reviewed information relevant to the distribution of UCR spring-run Chinook salmon in the Columbia River basin. The area of greatest exposure to the effects of the proposed action is the Columbia River from the mouth and plume[209] up to Chief Joseph Dam with respect to actions that affect flow. The area includes tributaries and their confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions in the Columbia River basin.

2.6.2.1 Mainstem Habitat

Mainstem habitat in the middle and lower reaches of the Columbia River has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., smallmouth bass, walleye, channel catfish, invertebrates, etc.), and other human activities that have degraded water quality and habitat.

2.6.2.1.1 Seasonal Flows

On the mainstem of the Snake and Columbia Rivers, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river take place in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows take place from September to February. During the winter, periodic peaks in flow occur due to heavy rain events

[209] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

(Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.6-3). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

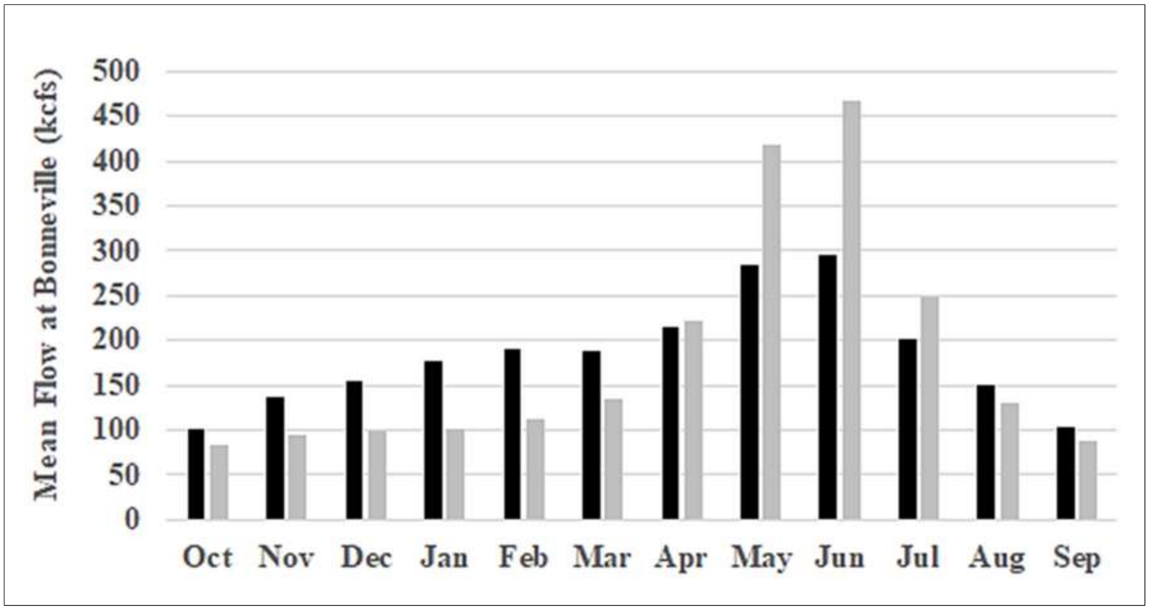

Figure 2.6-3. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[210] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year (Table 2.6-4). This has been accomplished by avoiding

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[210] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile SR spring/summer Chinook salmon and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

Table 2.6-4. Seasonal flow objectives and planning dates for the mainstem Columbia and Lower Snake Rivers. NA indicates that there is not a flow objective for the season at these projects.

Location	Spring		Summer	
	Dates	Objective (kcfs)	Dates	Objective (kcfs)
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100[a]	6/21 to 8/31	50 to 55[a]
Columbia River at McNary Dam	4/10 to 6/30	220 to 260[a]	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 to 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160[b]	NA	NA

[a] Objective varies based on actual and forecasted water conditions.

[b] Objective varies according to water volume forecasts and is for chum salmon (spawning period is approximately November 1 through December and protection flow objectives are based on redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

Seasonal flow objectives for improving the migration and survival of spring and summer juvenile migrants are based on water supply forecasts; however, mean seasonal flows in the past did not always achieve the flow objectives when measured as a seasonal average flow. From 1998 to 2019, seasonal spring flow objectives were met or exceeded during 81 percent of years at McNary Dam and during 48 percent of years at Lower Granite Dam. For the years when the spring flow objectives were not met, the average seasonal flow was 88 percent of the spring flow objective at McNary Dam and 78 percent of the spring flow objective at Lower Granite Dam. Across all years, the average percentage of the spring flow objective obtained was 113 percent at McNary Dam and 101 percent at Lower Granite Dam. Achieving these seasonal flow objectives provides multiple benefits for smolts in the migration corridor, estuary, and plume. Higher spring flow helps reduce fish travel time, increases juvenile access to shallow water habitat along the river banks, increases the flux of invertebrate prey to shoreline habitat, increases turbidity (which can reduce predation on juvenile migrants), and increases the size of the Columbia River plume, which is a key transition corridor for smolts to the nearshore ocean environment. Conversely, when seasonal flow objectives are not met, juvenile survival may be reduced via these same pathways of ecological effects.

From 1998 to 2019, summer flow objectives were met or exceeded during 14 percent of years at McNary Dam and during 18 percent of years at Lower Granite Dam. For the years when the summer flow objectives were not met, the average seasonal flow was 74 percent of the summer flow objective at McNary Dam and 66 percent of the summer flow objective at Lower Granite Dam. Across all years, the average percentage of the summer flow objective obtained was 85 percent at McNary Dam and 79 percent at Lower Granite Dam. The benefits provided by attaining summer flow objectives, and potential impacts associated with not meeting them, are the same as those previously described for the spring flow objectives, but very few UCR spring-run Chinook salmon smolts are migrating at this time of year.

Recommendations on when to manage flows for the benefit of juvenile passage are made by the TMT during the juvenile migration season. These recommendations are informed by the status of the juvenile migration, water supply forecasts, river flow conditions, and river flow forecasts during the juvenile migration season.

2.6.2.1.2 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult UCR spring-run Chinook salmon is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of UCR spring-run Chinook salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead survival is a concern; because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point source thermal discharges from cities and industries.
- Climate change.

Temperatures in the middle Columbia River are affected by Grand Coulee Dam, completed in 1942. Thermal inertia from the large mass of water in the reservoir (total storage capacity of 9.6 million acre-feet, active capacity of about 5.2 million acre-feet) results in delayed warming in the spring (cooler temperatures) and delayed cooling in the late summer and fall (warmer temperatures). Even in the extremely warm year of 2015, the average temperature of Grand Coulee outflows was less than 68°F (Figure 2.6-4) (NMFS 2016d), indicating little risk from this environmental parameter to spring migrating UCR spring-run Chinook salmon smolts. Cooler spring (April and May) temperatures in the middle Columbia River would reduce exposure to high temperatures and would be expected to enhance the survival of spring migrating smolts and adult UCR spring-run Chinook salmon. Warmer August and September temperatures would have little effect on adult UCR spring-run Chinook salmon because they would already have migrated into their natal tributaries by this time of year.

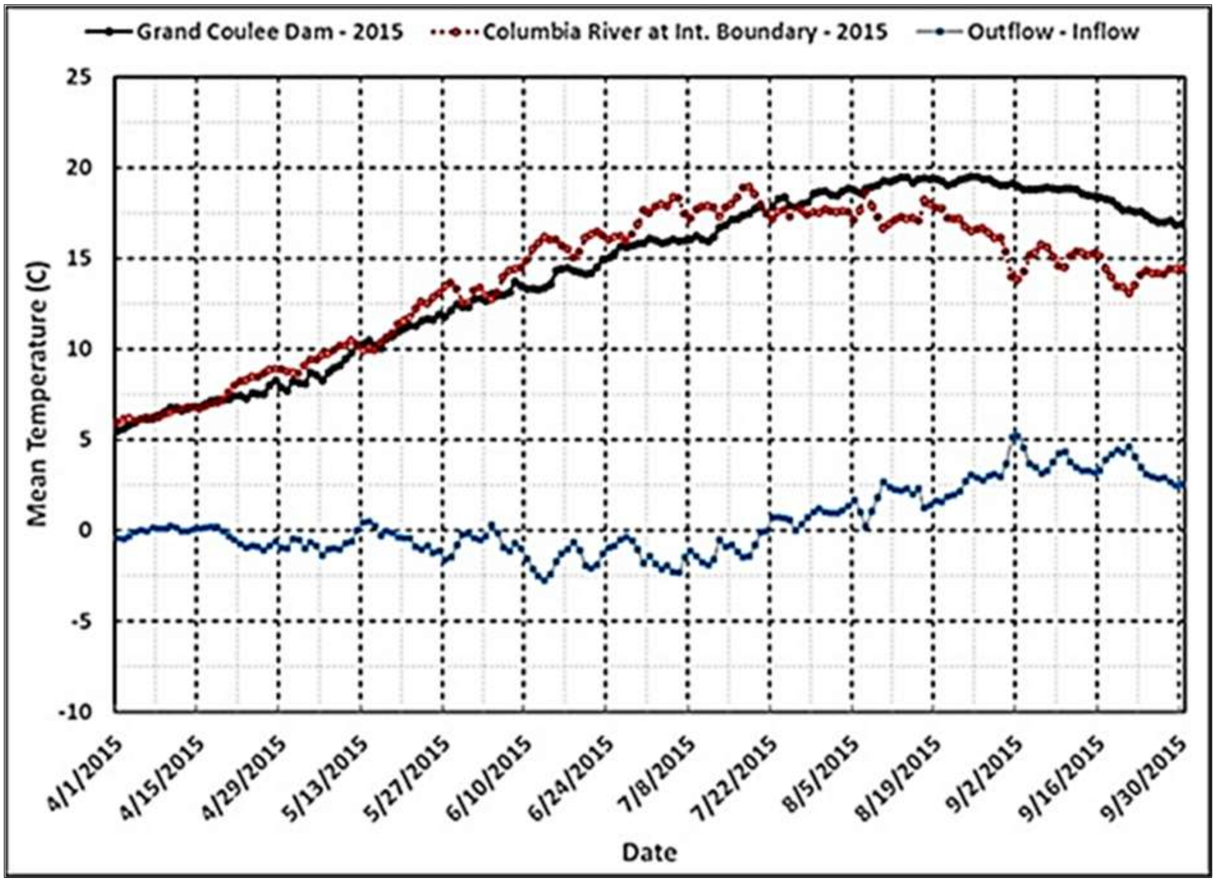

Figure 2.6-4. Outflow temperatures at Grand Coulee Dam compared to upstream Columbia River temperatures at the international boundary. Blue line indicates the difference (inflow – outflow) in temperature. Source: BOR Hydromet Data reported in NMFS 2016a.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period from 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the run-of-river dams and found three notable differences between the current and the unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the middle and lower reaches of the Columbia River likely have similar effects.

These hydrosystem effects (which stem from both upstream storage projects and run-of-river mainstem projects) continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broadscale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and at temperature extremes, survival.

The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the middle and lower Columbia River during spring, except for adult UCR spring-run Chinook salmon migrating at the end of their respective runs (June and July).

In May 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with Federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995a). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam, except The Dalles Dam. The FERC-licensed Wanapum Dam in the middle Columbia River reach also uses these structures to control TDG. Biological monitoring (smolts sampled from the juvenile bypass systems at many mainstem dams) shows that the incidence of observable GBT symptoms remains between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[211] Under recent operations (2008 to 2019), exposure to elevated TDG levels exceeding state standards was

[211] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

restricted to involuntary spill, most often between mid-May and mid-June, affecting most yearling spring Chinook salmon smolts and adults. Monitoring data from 1998 to 2018 indicate that TDG did not increase instantaneous mortality rates for juvenile yearling Chinook in the CRS (CSS 2019).

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

Sediment Transport

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.6.2.1.3 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of SR spring/summer Chinook salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[212] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[213] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA

[212] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[213] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river.

accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and, where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.6.2.1.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adults that are migrating past the dams or within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Very few adult and juvenile UCR spring-run Chinook salmon have been affected by these activities, because they predominantly migrate from April to July and scheduled maintenance activities are typically avoided during this migration period.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult UCR spring-run Chinook salmon has likely resulted in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes have minimized the impacts.

2.6.2.1.5 Adult Migration/Survival

Adult UCR spring-run Chinook salmon migrate from the ocean, upstream through the estuary, and pass between seven and nine mainstem dams and reservoirs to reach their spawning areas; all populations must pass the four lower Columbia River dams and between three and five mid-Columbia PUD dams. Factors that affect the survival rates of migrating adults include fish condition, harvest (either reported or unreported), dam passage (adults must find and ascend ladders and reascend the ladders if they accidentally fall back over the spillway), straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish (NMFS 2008a).

PIT-tag detectors placed in adult ladders at the mainstem dams provide a unique ability to monitor the upstream survival of adults that were tagged as juveniles. Starting with the number of adults detected at Bonneville Dam, minimum survival estimates can be derived from detectors at upstream dams. Termed “conversion rates,” these survival estimates are adjusted for reported harvest and the expected rate of straying of natural-origin adults.[214] Figure 2.6-5 depicts minimum estimated survival rates from Bonneville to McNary Dam (three reservoirs and dams) during 2010 to 2019, years that include recent hydropower operations and harvest rates within the “zone 6” fishery (as designated in the *U.S. v. Oregon* Management Agreements). Figure 2.6-5 also shows minimum estimated survival rates from McNary to Priest Rapids Dam (McNary Reservoir and the free-flowing Hanford reach of the Columbia River) or to Wells Dams (McNary to Priest Rapids Dam and an additional four reservoirs and dams) for fish released as juveniles upstream of Wells Dam and detected as adults at McNary Dam (2008 to 2017).[215]

[214] Using only known-origin fish adjusted for reported harvest and natural stray rates.

[215] All three mid-Columbia PUDs (Grant, Chelan, and Douglas) have achieved adult survival standards for UCR spring-run Chinook salmon. As a condition of their Federal license, all PUDs must evaluate adult survival at 10-year intervals to ensure that standards are maintained.

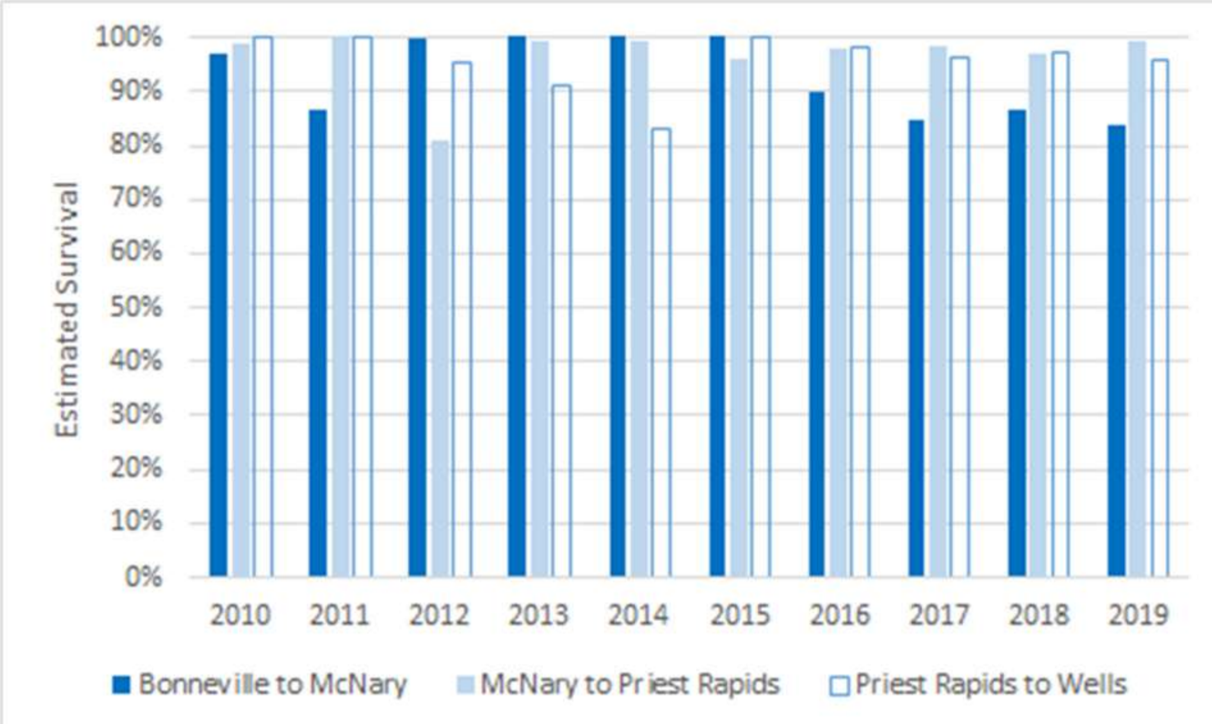

Figure 2.6-5. 2010–2019 survival estimates from Bonneville to McNary Dam (of known-origin PIT-tagged adult UCR spring-run Chinook salmon, natural- and hatchery-origin combined); McNary to Priest Rapids Dam, and Priest Rapids to Wells Dam (of known-origin PIT-tagged UCR adult Chinook salmon released upstream of Wells Dam as juveniles). Bonneville to McNary Reach estimates are corrected for harvest and straying. Priest Rapids to Wells survival was estimated using Cormack Jolly Seber methodology due to low PIT tag detection efficiency at Rock Island Dam.

As shown in Figure 2.6-5, the 10-year average minimum survival estimate for UCR spring-run Chinook salmon from Bonneville to McNary Dam is 93.9 percent (range of 83.8 to 100.0 percent). The average minimum survival estimate for UCR spring-run Chinook salmon released upstream of Wells Dam as juveniles was 94.7 percent (range of 91.2 to 97.9 percent) to Priest Rapids and 90.2 percent (range of 85.4 to 96.3 percent) to Wells Dam during this period. Comparing the McNary to Priest Rapids Dam reach to the McNary to Wells Dam reach indicates that average survival from 2008 to 2017 was about 95.4 percent through the Priest Rapids Reservoir; Wanapum, Rock Island, and Rocky Reach Dams and Reservoirs; and Wells Dam reaches.

These survival estimates account for total losses from the dams and reservoirs, as well as any losses in these reaches resulting from any flow effects, temperature, disease, or other natural causes. Expressed on a “per project” basis, about 97.8 percent of adult UCR spring-run Chinook salmon are surviving passage through each project (dam and reservoir) in the lower Columbia River after accounting for reported harvest and natural stray rates. From Priest Rapids to Wells Dam, per project survival rates are averaging around 98.8 percent.

2.6.2.1.6 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and non-native species that are predators, competitors, or food sources for migrating juvenile yearling Chinook salmon. The travel times of migrating smolts are increased through the reservoirs, increasing exposure to both native and nonnative predators (see Section 2.6.2.6.1), and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spill bays, or surface passage routes) (NMFS 2008a, b).

However, overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1999, when the species was listed. This is most likely the result of improved structures and operations and predator-management programs at the Corps' and FERC-licensed mainstem projects (24-hour spill, surface passage routes, improved juvenile bypass systems, etc.).

Tables 2.6-5 depicts the hydrosystem spillway operations for the five mid-Columbia PUD-owned dams (Douglas, Chelan, and Grant County). Table 2.6-6 depicts the Fish Operations Plan (FOP) for spring spill during 2017, 2018, 2019, and 2020 at the Action Agency-operated dams in the lower Columbia River. There was a substantial increase in spill over the dam spillways in the spring during 2018 in response to a court order requiring additional spill in the lower Columbia River. Spill levels in 2019 and 2020 using flexible spill, as proposed by the Action Agencies and consulted upon in the 2019 CRS biological opinion, were also higher than spill in 2017 at most projects. The spillways represent just one of several routes of passage through the dams. For example, the Wells project is constructed as a hydropower combine and utilizes modified spillway bays to efficiently pass juvenile salmon and steelhead past the project in a non-turbine route of passage.

Table 2.6-5. Summary of recent spring spill levels (percent of project outflow or kcfs) at mid-Columbia PUD projects.

Project	Recent Spring Spill Operations (Day/Night)
Wells	7% or more Uses up to five surface bypass entrances (modified spillway bays)
Rocky Reach	9%
Rock Island	10%
Wanapum	20 kcfs
Priest Rapids	27 kcfs

Table 2.6-6. Summary of 2017, 2018, 2019, and 2020 Fish Operations Plan spring spill levels (April 10 to June 15) at lower Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flex Spill	2020 Flex Spill
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)
John Day	**April 10–April 28:** 30%/30% **April 28–June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 40% Performance Standard (8 hours per day)	40%/40%
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)	120% TDG gas cap (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)	125% TDG gas cap up to 150 kcfs (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)

[1] Spill operations are described as percent of project outflow or kcfs.

Performance standards testing at the mid-Columbia PUD FERC-licensed projects indicates that recent average juvenile survival rates to the Priest Rapids tailrace are about 73.7 percent for juveniles from the Okanogan and Methow Rivers (five reservoirs and dams), 76.4 percent for juveniles from the Entiat River (four reservoirs and dams), and 81.1 percent for juveniles from the Wenatchee River (three reservoirs and dams).[216] This equates to average per project (reservoir and dam) juvenile survival rates of about 93 to 96 percent. Studies using hatchery Chinook salmon indicate that survival from release sites in the upper Columbia River to McNary Dam has averaged 55.7 percent in the last 20 years and was 50.6 percent in 2019 (Zabel 2019, Widener et al. 2020).

Zabel (2019) and Widener et al. (2020) estimate that hatchery-origin juvenile UCR spring-run Chinook salmon survival rates from McNary to Bonneville Dam (three reservoirs and dams) have ranged from 62.6 to 105.6 percent (2008 to 2019, an average of 81.2 percent).[217] In 2018, the estimate was 74.9 percent, slightly less than the average, and in 2019, the estimate was 78.5 percent, which was slightly lower than average but did not differ significantly.

[216] As a condition of their Federal license, all three mid-Columbia PUDs must evaluate juvenile survival at 10-year intervals to ensure that passage survival standards are maintained. All three mid-Columbia PUDs (Grant, Chelan, and Douglas) have achieved juvenile survival standards for UCR spring-run Chinook salmon.

[217] Survival estimates higher than 100 percent are possible. To calculate the 2008 to 2019 average, 1.00 was used for the survival value in 2013, rather than the 1.056 estimated value.

Together, these survival rates represent a substantial improvement in migration conditions and survival rates for juvenile UCR spring-run Chinook salmon migrating through the impounded reaches of the middle and lower Columbia River, compared to the survival rates during the 1970s to the mid-2000s.

2.6.2.1.7 Transportation

Juvenile fish transport has been used for mitigation in the CRS since 1981 (Baxter et al. 1996). At dams with juvenile bypass systems, turbine intake screens divert smolts away from turbine units and into a system of channels and flumes.[218] At dams with transportation facilities, diverted fish may be bypassed into the tailrace below the dam or collected in raceways where they can be loaded onto barges or trucks, transported below Bonneville Dam, and then released into the lower Columbia River to continue migrating to the ocean. The only dams in the CRS currently used for collection are Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam in the lower Snake River. UCR spring-run Chinook salmon were transported from McNary Dam from 1985 to 2012, after which all transport from McNary Dam ceased based on a recommendation from NMFS.

2.6.2.1.8 Mid-Columbia Public Utility District Projects in the Mainstem Columbia River

In 1998 to 2004, two PUDs (Chelan County and Douglas County) worked cooperatively with various state and Federal fisheries agencies, including NMFS, USFWS, WDFW, three Native American tribes, and an environmental organization, American Rivers, to develop the first hydropower HCPs (Habitat Conservation Plan) for salmon and steelhead. Under the HCPs, the two PUDs commit to a 50-year program to ensure that their projects have no net impact on UCR spring-run Chinook salmon and UCR steelhead. This will be accomplished through a combination of fish bypass systems, spill at the hydropower projects, off-site hatchery programs and evaluations, and habitat restoration work in tributaries to the Columbia River in the affected reach. The PUDs must meet minimum targets for either combined juvenile and adult survival or for juvenile-only survival through their reservoirs and past their dams. The minimum combined survival target is 91 percent, and juvenile-only survival target is 93 percent. The PUDs have met or exceeded those levels for all spring migrating salmon and steelhead species at the Rocky Reach, Rock Island, and Wells Development hydropower projects. Subsequently, FERC completed consultation on the renewal of the FERC license for the Wells Development Project (Douglas PUD) that carries those same commitments forward. Also, in the middle Columbia reach, FERC completed consultations on licenses to operate for two Grant PUD projects in 2008: Wanapum Development and Priest Rapids Development. The licenses and ESA consultations contain commitments for UCR spring-run Chinook salmon survival, consistent with current recovery planning.

[218] All of the powerhouses at the four lower Columbia River mainstem dams have juvenile bypass systems, with the exception of The Dalles Dam and Bonneville Dam, Powerhouse 1; Rocky Reach Dam is the only mid-Columbia PUD project which has a conventional screening system on some of its turbine units.

2.6.2.2 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

The Leavenworth National Fish Hatchery Complex consists of three large hatchery facilities: Leavenworth National Fish Hatchery, Entiat National Fish Hatchery, and Winthrop National Fish Hatchery, which are operated by USFWS.[219] The three hatcheries, authorized as part of the Grand Coulee Fish Maintenance Project in 1937, serve as mitigation facilities to compensate for the lack of access and loss of spawning and rearing habitat caused by the construction of Grand Coulee Dam. At the time, it was estimated that 85 to 90 percent of the fish counted at Rock Island Dam originated upstream from Grand Coulee Dam, and that about half of historical UCR spring-run Chinook salmon habitat was taken out of production by the construction of Grand Coulee Dam (UCSRB 2007).

Under settlement agreements and stipulations developed through FERC licensing processes, the three mid-Columbia PUDs also fund hatchery programs within the upper Columbia River basin. These programs are operated by the PUDs, Washington Department of Fish and Wildlife (WDFW), and the tribes. The settlement agreements determine the levels of hatchery production needed to mitigate the impacts of the construction and continued operation of the PUD dams and also contribute to the rebuilding and recovery of natural-origin populations in their native habitats, while maintaining their genetic and ecological integrity, and supporting harvest (UCSRB 2007). Although these hatchery programs emphasize use of local stocks, they may also affect the diversity and productivity of natural-origin stocks.

The hatchery programs that affect the UCR spring-run Chinook salmon ESU have changed over time, and these changes have likely reduced adverse effects on ESA-listed species. Specifically, the hatchery programs funded by the PUDs were reduced in size starting in 2012 because of a revised calculation of their mitigation responsibility based on increased survival through the PUD dams. Reducing hatchery production has reduced the number of natural-origin fish used for broodstock, along with the proportion of hatchery fish on the spawning grounds and associated genetic risk. Furthermore, as a result of completed site-specific consultations (NMFS 2013d, 2014d, 2016h, 2017j, 2017k), several additional reform measures have been implemented, such

[219] A fourth facility planned for the Okanogan River was never constructed.

as terminating the Entiat NFH spring Chinook salmon hatchery program, and genetically linking the two spring Chinook salmon programs in the Methow River subbasin.

2.6.2.3 Recent Ocean and Columbia River Harvest

UCR spring-run Chinook salmon are not targeted in ocean fisheries within the U.S. Exclusive Economic Zone and the coastal and inland marine waters of Washington, Oregon, and California. The harvest of upriver spring Chinook salmon, including those from the upper Columbia River, is assumed to be zero, or close to it, based on the timing of ocean fisheries, which allows spring-run Chinook salmon to enter freshwater areas before ocean salmon fisheries begin. The low levels of catch of all spring-run Chinook salmon have been verified by sampling performed annually in all ocean fisheries (NMFS 2018a). A recent examination of Chinook salmon stock ocean distribution using CWT data from 2006 to 2016 corroborates that UCR spring-run Chinook salmon still experience exploitation rates less than 1 percent across all marine fisheries combined (PFMC 2019).

Fisheries in the Columbia River basin, particularly in the mainstem Columbia River, are managed pursuant to plans developed by the parties to the *U.S. v. Oregon* management agreements. Parties to this process include the Federal government; the states of Oregon, Washington, and Idaho; the four Columbia River Treaty Tribes; and the Shoshone-Bannock Tribes. The majority of incidental mortality on natural-origin UCR spring-run Chinook salmon occurs in Columbia River mainstem tribal gillnet and dip net fisheries targeting spring and summer-run Chinook salmon. The 2008 to 2017 *U.S. v. Oregon* Management Agreement allowed for the incidental take of 5.5 to 17 percent of the total run of UCR spring-run Chinook salmon in spring fisheries, depending on abundance of upriver spring Chinook salmon. The range of estimated incidental take observed on the total run (2008 to 2018) was 8.8 to 16.7 percent and averaged 10.6 percent, which is within the limits set in the management agreement. These harvest rates are substantial reductions compared to those that occurred before the 1990s.

NMFS recently signed the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Under this new management agreement, incidental harvest of UCR spring-run Chinook salmon is again limited to no more than 17 percent of the total estimated run size at the mouth of the Columbia River, but harvest will vary based on annual expected returns, with rates decreasing at lower return sizes. The agreement continues to support salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho and to ensure fair sharing of harvestable fish between tribal and non-tribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*. NMFS' biological opinion addressing the effects of the 2018 to 2027 *U.S. v. Oregon* Management Agreement (NMFS 2018a) concluded that the effects of fisheries were not likely to jeopardize the continued existence of the UCR spring-run Chinook salmon ESU.

Mark-selective fisheries occur for spring-run Chinook salmon in the Wenatchee River subbasin and above Wells Dam (NMFS 2016f, 2017j). Steelhead fisheries also operate in the upper Columbia under permit 1395 (NMFS 2003), permit 18583 (NMFS 2016f), and NMFS (2017j). Few to no encounters with spring Chinook salmon have occurred or would be expected to occur in the steelhead fisheries because they take place from September through March and do not overlap in time with the presence of UCR spring-run Chinook salmon adults. Fisheries for non-ESA-listed fish also occur that may have incidental impacts on UCR spring-run Chinook salmon, and are covered under permit 1554 (NMFS 2008c) and NMFS (2017j). NMFS did not find any of these fishery activities to appreciably reduce the likelihood of survival and recovery of UCR spring-run Chinook salmon.

2.6.2.4 Tributary Habitat

2.6.2.4.1 ESU Overview

Tributary habitat conditions in the subbasins within the UCR spring-run Chinook salmon ESU (i.e., the Wenatchee, Entiat, and Methow subbasins) are generally good in high elevation reaches but degraded in lower elevation reaches, particularly near valley bottoms (UCSRB 2007, 2014). The ability of habitat in these upper Columbia subbasins to support the viability of UCR spring-run Chinook salmon is generally limited by one or more of the following factors: 1) reduced stream complexity and channel structure, 2) reduced floodplain condition and connectivity, 3) degraded riparian conditions, 4) diminished stream flow, 5) impaired fish passage, 6) excess fine sediment, and 7) elevated summer water temperatures (UCSRB 2007). A 2014 synthesis report on the status of habitat in the Upper Columbia region (UCSRB 2014) found that the limiting factors of highest concern for the region are instream structural complexity, riparian conditions, bed and channel form, and increased sediment. The combination, intensity, and relative impact of these factors vary locally throughout each subbasin, depending on historical and current land use activities and natural conditions.

Human activities that have contributed to these limiting factors include dams, water diversions, stream channelization and diking, roads and railways, timber harvest, grazing, and urban and rural development (UCSRB 2015). Natural disturbance has recently also had a large effect on habitat in the upper Columbia River basin. For instance, in 2014 the Carlton Complex fire, the largest ever recorded in Washington, burned approximately 253,377 acres. Fires are natural disturbances that, from an ecological perspective, over time help facilitate the development and maintenance of the complex habitats needed by salmonids (Bixby et al. 2015, Flitcroft et al. 2016). However, in the near term, the Carlton Complex fire has and will likely continue to result in higher runoff rates, higher impacts (e.g., increased runoff and erosion leading to increased sediment load and streambed scouring) from rain and snow events, and increased sedimentation, with associated adverse effects on salmon productivity (UCSRB 2015).[220] Changes in precipitation and temperature have also influenced trends in habitat, with average temperatures increasing over the past three decades and precipitation decreasing, resulting in decreased

[220] For example, in August 2014, a heavy rain storm occurred across the Carlton Complex area and produced extensive run-off that led to severe hillslope erosion and debris flows in some areas that caused substantial channel scour, down cutting, bank erosion, and sedimentation. In addition, some road crossings failed as a result of the debris flows. Streams affected included fish-bearing streams and the mainstem Methow River, which received a substantial volume of fine sediment that caused high turbidity all the way to the Columbia River. Extensive fish mortality resulted in the Methow River and in Beaver and Frazer Creeks.

snowpack and changes in runoff patterns and exacerbated low flow issues in some areas (UCSRB 2014).

In general, land use practices and regulatory mechanisms have improved from historical practices and regulations (UCSRB 2007, 2014). Roper et al. (2019), for instance, reviewed the status and trends of 10 stream habitat attributes to evaluate whether changes in Federal land management had altered the trajectory of stream habitat conditions in the interior Columbia River basin. They concluded that changes in management standards and guidelines in the 1990s are related to improved stream conditions, although they were not able to determine the precise magnitude of the changes. In addition, while new development appears to be a relatively minor factor in landscape change in the region (based on an assessment in a representative area by the State of Washington [UCSRB 2015]), ongoing development and land-use activities may continue to have negative effects.

Many habitat restoration actions have been and are being implemented in these subbasins through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies (UCSRB 2007, 2014; BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). The Action Agencies have been implementing tributary habitat improvement actions as part of mitigation for the CRS since 2007. These actions have included protecting and improving stream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. The actions are generally targeted toward addressing the limiting factors identified above (BPA et al. 2013, 2016, 2020). Cumulative metrics for these action types for UCR spring-run Chinook salmon from the years 2007 to 2019 are shown in Table 2.6-7.

Table 2.6-7. Tributary habitat improvement metrics: UCR spring-run Chinook Salmon, 2007–2019 (BPA et al. 2020, McLaughlin 2020).

Action Type*	**Amount Completed**
Acre-feet/year of water protected *(by efficiency improvements and water purchase/lease projects)*	27,344
Riparian acres protected *(by land purchases or conservation easements)*	323
Riparian acres improved *(to improve riparian habitat, such as planting native vegetation or control of noxious weeds)*	440
Miles of enhanced or newly accessible habitat *(by providing passage or removing barriers)*	117
Miles of improved stream complexity *(by adding wood or boulder structures or reconnecting existing habitat, such as side channels)*	34
Miles protected *(by land purchases or conservation easements)*	10

Action Type*	Amount Completed
Screens installed or addressed *(for compliance with criteria or by elimination/consolidation of diversions)*	14

* Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have improved and will continue to improve habitat in the targeted populations as these projects mature, and that fish population abundance and productivity will respond positively. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions). Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

RME has been underway in this ESU to evaluate changes in habitat and fish populations as a result of habitat improvement actions. Available empirical evidence supports our view that these actions are improving habitat capacity and productivity, and that fish are responding. Below, we include limited examples of RME results specific to UCR spring-run Chinook salmon, while Appendix A summarizes the scientific foundation for our determination, including relevant RME information from throughout the Columbia River basin and other lines of evidence that we considered regarding the effects of habitat improvement actions. It also discusses the complexities of evaluating the effects of habitat restoration on fish populations (see Appendix A;

also see NMFS 2014a, Hillman et al. 2016, Griswold and Phillips 2018, ISAB 2018, Haskell et al. 2019).[221]

For the Wenatchee River population, NMFS used life-cycle modeling to evaluate the effects of tributary habitat improvement actions implemented to date. Results of these evaluations are summarized below, and the models and results are described in more detail elsewhere in this section and in supporting documents (Jorgensen et al. 2013, 2017; Pess and Jordan, eds. 2019; Jorgensen and Bond 2020).

The best available scientific and technical information also indicates that there is additional potential to improve habitat productivity in these populations, and that additional improvements are needed to achieve recovery goals (UCSRB 2007, 2014, 2015; NMFS 2016d, UCRTT 2017). Density dependence has been observed to varying degrees in UCR spring-run Chinook salmon populations (UCSRB 2007, ISAB 2015), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stages and limiting factors, would be likely to improve overall population abundance and productivity. The Entiat River population exhibits strong and unambiguous density dependence. For the Methow River population, freshwater productivity for spring Chinook salmon is likely to be limited by rearing habitat or food in some tributaries but not in the Methow subbasin overall (ISAB 2018).

An Upper Columbia Salmon Recovery Board assessment in 2014 concluded that the highest priority in the upper Columbia region for increasing habitat productivity in degraded areas is to restore the stream channel complexity and floodplain function, where possible, by promoting and restoring the ecological processes that affect habitat diversity, instream flows, and water quality. Protection of existing stream flows in virtually all subbasins in the region is also important to maintaining biological productivity. In addition, these types of actions have the added benefit of increasing climate change resilience. Several planning processes have provided detailed assessments that identify the highest priority areas that are the most appropriate for reach-scale restoration and protection programs. Within the past several years, habitat restoration has shifted toward larger-scale projects designed to address reach-based ecological concerns (UCSRB 2014).

More detail on tributary habitat conditions for the three populations that constitute this ESU is provided below.

[221] The goal of the tributary habitat program is to implement tributary habitat actions that address priority limiting factors and improve population abundance, productivity, spatial structure, and diversity. Measuring the effects of habitat restoration for fish and other aquatic and riparian biota is "one of the great challenges of river and stream conservation" (ISAB 2018). To draw conclusions about the benefits of tributary habitat improvements, we evaluated multiple lines of evidence, including knowledge of the basic relationships between fish and their tributary habitat, findings in the scientific literature about how changes in fish habitat affect fish populations, literature on the physical and biological effectiveness of tributary habitat improvement actions, correlation analyses, results from monitoring in the Columbia River basin designed to evaluate the effects of various actions on tributary habitat limiting factors and on salmon and steelhead population response, and the results of life-cycle models. Those lines of evidence and our general conclusions are summarized in Appendix A.

2.6.2.4.2 Methow Subbasin

In the Methow River subbasin, upper portions of major tributaries contain a high proportion of intact habitat. The primary habitat conditions in the Methow River subbasin that currently limit abundance, productivity, spatial structure, and diversity of salmon and steelhead are mostly found in the middle and lower mainstem and lower portions of major tributaries. In these areas, road building, residential development, and agricultural practices have diminished stream complexity, wood and gravel recruitment, floodwater retention, and water quality, negatively affecting the ability of these habitats to support spring-run Chinook salmon. Late summer and winter instream flow conditions also often reduce migration, spawning, and rearing habitat for salmonids. This is partly natural (a result of watershed-specific weather and geomorphic conditions) but is exacerbated by irrigation withdrawals (NMFS 2016d, UCRTT 2017).

Numerous partners, including Federal, tribal, and state agencies; utilities; private landowners; and nonprofit groups, have implemented a host of aquatic habitat enhancement actions in the Methow subbasin over the past two decades. Overall, work in the Methow subbasin has involved over 50 partners and over 100 enhancement projects. Restoration actions in this subbasin have been targeted toward addressing limiting factors and have included protection and restoration of stream flow, screening of irrigation diversions, improving access to habitat, improving stream complexity and floodplain connectivity, and restoring riparian areas (BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). Actions have been based on increasingly detailed plans and assessments that identify limiting factors, ecological concerns, and action opportunities and prioritizations (see, e.g., UCSRB 2007, BOR 2008; UCRTT 2013, 2017). Various entities have conducted assessments covering approximately one-fifth of the entire stream length in the Methow subbasin since 2008. This enhanced information base provides improved ability to identify actions that will provide the greatest benefit.

The type and quantity of improvement actions has changed over time. Early projects, in the late 1990s, were primarily related to upgrading inadequate fish screens and screening unscreened diversions. Passage improvements included barrier removals associated with irrigation diversions in Beaver Creek in the mid-2000s that removed barriers to adult and juvenile fish. More recently, instream flow and habitat enhancement actions (e.g., improved instream complexity and floodplain and side-channel connectivity) have been the focus in the subbasin, primarily in the middle and upper mainstem Methow River, the Twisp River, the Chewuch River, and numerous smaller tributaries. Implementation of these habitat actions increased substantially beginning in 2008, with the largest number of actions implemented in 2013 through 2017. Since 2017, the number of enhancement actions implemented per year has decreased, but the complexity and size of recent actions has increased. Taken together, these actions span a wide range of types, intensities, and sizes, and have resulted in a range of ecological responses (BOR 2019a). Best available science indicates that they have improved and will continue to improve habitat function for the Methow River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). Status and trends monitoring, action effectiveness monitoring, and development of ecological models in the basin have provided information to help understand the effects of the actions and inform development and implementation of more effective actions in the future. Some of the relevant results include the following:

- In the first year of monitoring following implementation of floodplain and channel habitat improvement actions in the Methow subbasin, restored sites experienced increased seasonal connectivity to the mainstem, increased overall habitat capacity, increased pool depths, and increased large wood cover, and each showed an increase in juvenile salmon and steelhead rearing densities compared to control sites (Martens et al. 2014). Subsequent years of post-treatment monitoring observed smaller increases in juvenile abundance (Hutcherson et al. 2018). Although not conclusive, these results are generally consistent with findings from other studies that have shown higher densities of Chinook and steelhead in treated versus untreated areas (BOR and BPA 2013, Polivka et al. 2015, Polivka and Claeson 2020).
- An evaluation of fish passage enhancement in Beaver Creek (a tributary to the Methow) demonstrated that passage was successfully restored to portions of Beaver Creek (Grabowski 2013, Weigel et al. 2013). Juvenile and adult steelhead migration were improved, and juvenile spring Chinook were found upstream where they had not been detected before. Adult recolonization occurred slowly following the barrier removal and was possibly affected by the 2011 flood and 2014 forest fire and subsequent flooding.
- Available data on fish use in the basin provides information on use patterns, trends, and potential responses to habitat enhancement efforts. The monitoring to date has yielded some results suggesting that enhancement efforts in the basin are improving salmonid survival and productivity and the effects of enhancement actions on salmon and steelhead in the Methow River are expected to become more apparent as additional years of post-implementation data are collected (BOR 2019a).

The Methow River population is currently at high risk and must achieve at least viable status to meet ESA recovery goals (UCSRB 2007). There remains additional potential for improvement in habitat productivity in this population (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and improvement is needed to restore habitat to levels that will support a viable population.

2.6.2.4.3 Entiat Subbasin

While the majority of land in the Entiat subbasin is under public ownership, the lower basin, including more than 70 percent of the stream length accessible to salmon and steelhead, is privately owned. Historical land uses of mining, water diversion, and timber harvest reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many areas. The primary habitat conditions in the Entiat subbasin that currently limit salmon and steelhead include reduced stream channel complexity from logging, and flood control measures that straightened and removed large wood from the channel. These historical and ongoing activities have led to low instream habitat diversity, including few pools, lack of large wood, and disconnected side channels, wetlands, and floodplains. The result is a reduction in resting and rearing areas for both adult and juvenile salmon throughout the Entiat River (NMFS 2016d, UCRTT 2017).

Restoration actions in this subbasin have included protection and restoration of streamflow, improvements to passage barriers, improved stream channel complexity and floodplain connectivity, and riparian area improvements (BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). These actions have been targeted toward addressing limiting factors, and best available science indicates that they have improved and will continue to improve habitat function for the Entiat River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over the next several decades (see Appendix A). As in other subbasins in the region, work in the Entiat is guided by geomorphic reach assessments, which cover over 90 percent of the anadromous habitat in the area.

Some habitat improvement actions in the Entiat subbasin were implemented in 2012, 2014, and 2018 through 2019 under a structured and monitored approach through the Entiat River Intensively Monitored Watershed (IMW). Reduced instream complexity was the primary concern limiting Chinook salmon production in the lower 26 miles of the Entiat River. Current land uses (primarily agriculture, roads, and residential development) restricted habitat improvement options in this portion of the river, so an engineered approach was implemented to increase complexity, including adding rocks and large wood to the river, and reconnecting the floodplain by breaching levees where possible. So far, three of four planned rounds of habitat actions have been completed, affecting a majority of the targeted IMW reaches (additional implementation of actions is planned over the next several years in these reaches). The following are some of the relevant monitoring results:

- Habitat monitoring has shown a significant increase in the volume of wood in the Entiat River. No other habitat or geomorphic metrics have yet shown a response to the treatments, perhaps because insufficient time has elapsed for the response to occur (ISEMP/CHaMP 2015, 2016).
- Fish are using treated areas. For example, higher densities of juvenile Chinook salmon use off-channel habitats compared to main channel locations within the Entiat River (Hillman et al. 2016). Polivka et al. (2015) also found that Chinook salmon were more abundant in improved pools than in untreated pools in early summer. Polivka and Claeson (2020) surveyed reaches of the Entiat River treated with engineered logjams and reaches without treatments to determine if restoration had increased habitat capacity. They found that the density of juvenile Chinook salmon and steelhead was 3.1 and 2.7 times greater, respectively, in treated habitat compared with untreated habitat. To distinguish whether these density differences were actual increases in capacity rather than fish moving from poor habitat to good habitat, they compared density in unrestored habitat in both treated and untreated reaches. They found no differences for either species, confirming that the increased density in restored habitat units did not come from depletion of unrestored habitat in the same reach. Thus, they concluded that the

restoration had increased the habitat capacity of the reach at the scale of pools created by engineered logjams.

- Researchers have not yet found significant fish population responses (Hillman et al. 2016), but it is challenging to detect a population response to improvement actions. In addition, the Entiat River has not yet experienced the high post-treatment flows needed to affect channel morphology as hypothesized. Furthermore, only 50 percent of the enhancement plan has been implemented to date (Hillman et al. 2016). However, these early results are encouraging because they show that habitat is changing and fish are using the improved habitat.

The Entiat River population is currently at high risk and must achieve at least viable status to meet ESA recovery goals (UCSRB 2007). There remains additional potential for improvement in habitat productivity in this population (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and improvement is needed to restore habitat to levels that will support a viable population.

2.6.2.4.4 Wenatchee River Subbasin

In the Wenatchee River subbasin, although less than 25 percent of the subbasin is privately owned, nearly two-thirds of the lineal area of anadromous streams, primarily lower gradient streams, is bordered by private lands. The Wenatchee River subbasin was also affected historically by mining, intensive livestock grazing, agriculture, water diversions, timber harvest, and railroad and road building. These land uses have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many areas within the basin. However, some headwater areas are in relatively pristine condition and serve as strongholds for listed species. The primary habitat conditions in the Wenatchee River basin that currently limit abundance, productivity, spatial structure, and diversity of salmon and steelhead are a lack of habitat diversity and quantity, excessive sediment load, obstructions to fish passage (primarily diversion dams and impassable culverts), a lack of channel stability, low flows, and high summer stream temperatures. Habitat diversity is affected by channel confinement, loss of floodplain connectivity and off-channel habitat, reduced quantities of large wood, and a lack of riparian vegetation. The mainstem and many of its tributaries also lack high-quality pools and spawning areas associated with pool tail-outs. The lack of pools in many areas is probably directly related to the loss of riparian vegetation, removal of large wood, and channel confinement (NMFS 2016d, UCRTT 2017).

Restoration actions in this subbasin have included actions to protect streamflow, improve access, improve stream complexity, protect intact habitat areas, and improve riparian areas (BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). Work has generally focused in several key areas of salmon and steelhead production, including Nason Creek, the White River, the Chiwawa River, the lower Wenatchee River, Mission Creek, Peshastin Creek, Chumstick Creek, and Icicle Creek. The actions have been targeted toward addressing limiting factors, and best available science indicates that they have improved and will continue to improve habitat function for the Wenatchee River population and that fish population abundance, productivity, spatial structure, and diversity will respond positively. Benefits of some of these actions will continue to accrue over the next several decades (see Appendix A).

NMFS used a life-cycle model to assess the proposed action (see Section 2.6.3.1.12). As part of this assessment, modelers evaluated the effects of tributary habitat actions implemented in 2009 through 2018 on the Wenatchee River population.[222] The modeling assessed how a specific set of actions might change juvenile rearing capacity in major tributaries to the Wenatchee River (Jorgensen et al. 2013, 2017; Pess and Jordan, eds. 2019, Jorgensen and Bond, 2020).[223] There were four habitat actions completed during this period that were located in the spawning and rearing areas evaluated and that were quantifiable into changes in habitat capacity. These actions translated to a 7.6 percent increase in capacity in the Nason Creek watershed and a 1.7 percent increase in the White River watershed (Jorgensen and Bond 2020). Changes in abundance of natural-origin spawners and extinction risk for this population as a result of these actions are captured in the life-cycle modeling results discussed in Section 2.6.3.1.12. Other completed actions that could not be quantified into changes to habitat capacity, such as actions that improved streamflow and riparian areas, or land purchases and conservation easements (which are directed at preserving existing functional habitats), were not evaluated but are also expected to benefit this population now and into the future. Further, the modeling may not have captured all benefits attributable to the specific actions that were evaluated (Jorgensen and Bond 2020).

The Wenatchee River population is currently at high risk and must achieve at least viable status to meet ESA recovery goals (UCSRB 2007). There remains additional potential for improvement in habitat productivity in this population (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and improvement is needed to restore habitat to levels that will support a viable population.

2.6.2.4.5 ESU Summary

While some degraded areas in the UCR spring-run Chinook salmon ESU are likely on an improving trend due to past habitat improvement actions and improved land-use practices, in general tributary habitat conditions are still degraded. These degraded habitat conditions continue to negatively affect spring-run Chinook salmon abundance, productivity, spatial structure, and diversity, and present a major obstacle to achieving UCR spring-run Chinook salmon recovery. In addition, ongoing development and land-use activities may also have negative effects into the foreseeable future. All three populations in the ESU are currently at high risk and all three must achieve at least viable status under the ESA recovery plan (UCSRB

[222] Although habitat improvement actions were underway in this ESU before 2009, modelers used 2009 as a starting point because they viewed actions completed before then less likely to yield benefits as a result of having been more opportunistic, smaller actions implemented without the benefit of comprehensive tributary and reach assessments and other planning tools. Metrics for actions completed in 2019 were not yet available at the time the life-cycle modeling was completed.

[223] Actions completed in areas with little or no occurrence of spring Chinook salmon at present were excluded from the evaluation, as were actions completed in the mainstem Wenatchee River, because there is uncertainty whether juvenile rearing capacity is limiting there and little spawning takes place there at present.

2007). There remains additional potential for improvement in habitat productivity in all three populations (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and additional improvement is needed to restore habitat to levels that will support viable UCR spring-run Chinook salmon populations.

2.6.2.5 Estuary Habitat

The Columbia River estuary provides important migration habitat for yearling UCR spring-run Chinook salmon. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary such as those highlighted in the most recent 5-year review (NMFS 2016g) have improved access and connectivity to floodplain habitat. From 2007 through 2019, the Action Agencies implemented 64 projects, including dike and levee breaching or lowering, tide gate removal, and tide gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents more than a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling Chinook salmon (Johnson et al. 2018). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Floodplain habitat restoration can affect the performance of juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but the prey items produced in wetlands (primarily chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) are also exported to the mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Thus, while most yearling Chinook salmon may not enter a tidal wetland channel, they derive benefits from wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry. Blood serum levels of IGF-1 (Insulin-like growth factor-1) for yearling Chinook salmon collected in the estuary were higher than are typically found in hatchery fish before release, suggesting that prey quality and quantity in the estuary were sufficient for growth (PNNL and NMFS 2020). However, variation in IGF-1 levels was substantial (two to three times higher in some individuals than in others) (Beckman 2020), both within and between genetic stocks, indicating differences in feeding and migration patterns. Continuing to grow during estuary transit may be part of a strategy to escape predation during the ocean life stage through larger body size.

As discussed in Section 2.6.2.1.2, habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007), from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as it receives contaminants from more than 100 sources that discharge into a river and numerous sources of runoffs (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing the fact that contaminants are widespread throughout the estuarine food web (Fuhrer et al. 1996, Tetra Tech 1996, LCREP 2007). This includes the bodies of insects, which salmon in turn ingest. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.6.2.6 Predation

A variety of avian and fish predators consume juvenile UCR spring-run Chinook salmon on their migration from tributary rearing areas to the ocean. Many native (e.g., northern pikeminnow, trout, etc.) and non-native fish predators (e.g., smallmouth bass, walleye, brook trout, etc.) are known to consume rearing and migrating juvenile Chinook salmon in tributary streams and in the mainstem Columbia River. Many avian predators (e.g., Caspian terns, cormorants, pelicans, herons, kingfishers, etc.) and mammals (e.g., river otters, mink, raccoons, black bears, etc.) are also known to consume juvenile Chinook salmon, and in some cases adults (UCSRB 2007). Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. The following paragraphs discuss predation rates and describe management measures to reduce the effects of the growth of predator populations within the action area.

2.6.2.6.1 Avian Predation

Avian Predation in the Lower Columbia River Estuary

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river’s estuary and plume is about 40 percent of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including UCR spring-run Chinook salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island, where marine forage fish were available to diversify the terns' diet. Roby et al. (2017) estimated that terns on East Sand Island consumed an average of 5.1 million smolts per year, a 59 percent reduction from when the colony was on Rice Island.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this ESU were about 4.3 and 3.8 percent, respectively, before efforts to manage the size of these colonies (Evans and Payton 2020). Tern predation rates have decreased to 1.9 percent since 2007, a statistically credible difference (Appendix B). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on UCR spring-run Chinook salmon in 2003 to 2014 was 3.8 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[224] where smolts are likely to constitute a larger proportion of the cormorants' diet. The average annual predation rates on UCR spring-run Chinook salmon reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (4.1 during 2015 to 2017 and 0.6 percent in 2018) therefore cannot be directly compared to those before management began, and are likely to underestimate predation rates in the estuary.

Avian Predation in the Hydrosystem Reach

The following paragraphs describe aviation predation in the mainstem Columbia River from the tailrace of Bonneville Dam to confluences of the Wenatchee, Entiat, and Methow Rivers.

UCR spring-run Chinook salmon survival is affected in the mainstem by avian predators that forage at the mainstem dams and in the reservoirs. The 2008 biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and

[224] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84 to 94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[225]

Juvenile UCR spring-run Chinook salmon migrating are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. The objective of the IAPMP (USACE 2014) is to reduce predation rate to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been focused on keeping terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015, and similar efforts by Reclamation are in progress at Goose Island. Predation rates on this ESU, which were 2.5 percent for terns on Goose Island before implementation of the IAPMP, were reduced to less than 1 percent (predation rates for terns on Crescent Island and North Potholes Island remained 0.5 percent or less) (Evans and Payton 2020) (Appendix B). However, movement of terns to Blalock Islands in John Day Reservoir (Collis et al. 2019) increased predation rates on UCR spring-run Chinook salmon from less than 0.1 percent to 0.8 percent (Evans and Payton 2020), indicating very little if any change in the likelihood of survival.

Predation by gulls was not considered to warrant management actions at the time the IAPMP was developed, and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this ESU by gulls on Miller Rocks averaged 2.1 percent during 2007 to 2019 (Evans and Payton 2020) (Appendix B). Predation rates on UCR spring-run Chinook salmon were less than 2 percent per colony for gulls nesting on Island 20, Badger, Crescent, and Goose Islands in recent years (Evans and Payton 2020).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on UCR spring-run Chinook salmon after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin.

[225] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous water birds at the Corps' dams" (Zorich et al. 2012).

To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts overestimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead, and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different although related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood we are able to influence adult returns, but the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, also will be important.[226]

With respect to management of terns in the estuary, Caspian terns nesting on East Sand Island were eating an annual average of 4.3 percent of juvenile UCR spring-run Chinook salmon outmigrants before management actions reduced the size of that colony, and 1.9 percent per year thereafter (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (4.3 percent) and the average 2.4 percent per year decrease achieved by reducing the size of the tern colony, and that some level of compensation is likely to occur in the ocean even during favorable ocean years, it is likely that this management measure did not lead to increased adult returns for UCR spring-run Chinook salmon. For double-crested cormorants, reduction of the colony on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 3.8 percent to less than 1 percent, a small decrease. However, in this case, predation rates on UCR spring-run Chinook salmon are likely to have

[226] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

increased because thousands of these birds are now foraging from the Astoria-Megler Bridge where they are farther from marine forage fish prey base.[227]

2.6.2.6.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia and Snake Rivers followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). From 2015 to 2019, an annual average of 43 adult, 18 jack, and 104 juvenile Chinook salmon were incidentally caught in the Sport Reward Fishery (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were UCR spring-run Chinook salmon.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). They also reported an average of one adult and zero juvenile Chinook salmon killed or handled per year. In addition, they caught, but did not remove, an annual average of 967 smallmouth bass and 379 walleye at the two dam angling sites combined over the last 5 years (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). The Oregon and Washington Departments of Fish and Wildlife, which manage these two non-native predator species, are currently discussing the possibility of removing smallmouth bass and walleye from the system when captured by the Dam Angling Program (as with pikeminnow). Both agencies have already removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these species, in addition to pikeminnow, both in the lower

[227] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

Columbia River and the CRS reservoirs (i.e., hydrosystem reach), would incrementally improve juvenile salmonid survival during their migration to the ocean.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile Chinook salmon, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. Williams et al. (2018) found a lower than average abundance (1990 to 2018) for northern pikeminnow in The Dalles and John Day Reservoirs along with a two to three times higher than average abundance for smallmouth bass and walleye in the same reservoirs. With the exception of the John Day forebay area, smallmouth bass abundance index values calculated for 2018 were the highest observed since 1990. Abundance index values provide a means to characterize relative predation impacts (Williams et al. 2018). Similarly, in 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP, as well as a substantial increase in their predatory impact in the lower Snake reservoirs since program design and implementation. Also compared to previous years, walleye were relatively abundant in both The Dalles and John Day Reservoirs during 2018 spring sampling, but few were encountered during the summer sampling. The greatest walleye abundance indices were observed in the John Day Dam tailrace and mid-reservoir, with the tailrace value being the highest recorded abundance to date (Williams et al. 2018). These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal still remains unclear. The complexity of inter-species interactions, combined with inter-reservoir variability and environmental variability, make this a difficult research question to answer without a more intensive sampling and evaluation program (Williams et al. 2018, Winther et al. 2019). However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the Chinook salmon that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including UCR spring-run Chinook salmon. As such, it likely continues to benefit the ESU.

2.6.2.6.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions *(Zalophus californianus)*, Steller sea lions *(Eumetopias jubatus)*, and harbor seals *(Phoca vitulina)* all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace Bonneville Dam. ODFW counted the number of individual California sea lions hauling out in the Columbia River mouth at the East Mooring Basin in Astoria, Oregon, from 1997 to 2017. Individual pinniped counts at East Mooring Basin have steadily increased since the inception of the observation program with rapid increases within the last decade (Wright 2018). Within the Columbia River, the abundance of pinnipeds peaks in the spring when UCR spring-run Chinook salmon adults are migrating through the estuary.

Based on pinniped count data and spring Chinook salmon survival estimates, increasing pinniped abundance in the Columbia River estuary has resulted in an increased loss of UCR spring-run Chinook salmon in recent years. Rub et al. (2019) conducted a 5-year mark-recapture tagging study to examine the behavior and survival of spring Chinook salmon returning to the interior Columbia River basin (above Bonneville) amid increasing pinniped abundance. Using spring Chinook salmon that were known through genetic testing to originate above Bonneville Dam, these researchers found that average natural mortality for adult spring Chinook through this reach ranged from 20 to 44 percent over the 5-year study and survival was lowest during the most recent 2 years of study. It is important to note that while mortality due to harvest was accounted for, effects from capture, handling, disease, and straying effects were not accounted for in these estimates. These researchers found strong evidence that the recent increases in spring Chinook salmon loss estimates were a function of the large increase in pinnipeds counted from 2012 to 2015. This study provided estimates that were consistent with bioenergetics modeling, suggesting that increasing numbers of pinnipeds within the Columbia River are associated with reductions in the survival of returning adult Chinook salmon, most likely due to predation.

Chinook salmon populations exhibit a range of migration timings due to their different migration strategies adapted in response to phenology of migration, spawning and juvenile rearing habitat conditions. For UCR spring-run Chinook salmon, survival is typically lowest overall for fish migrating earlier in the run. Research has consistently found that the highest proportional impact of predation losses were experienced by fish that returned to the dam during late winter and early spring compared to those that followed. In 2013 to 2015, survival was especially low for early migrants, corresponding with a period of increased California sea lion presence in the estuary (Keefer et al. 2012). Early migrating spring Chinook salmon populations experienced a 22 percent reduction survival in 2013 to 2015, relative to a baseline period of 1998 to 2012, and survival of later-migrating populations declined by only 4 to 16 percent (Figure 2.6-6) (Sorel et al. 2017). The current information indicates that salmon populations with relatively early migration timing are more at risk since the relative predator density (number of predators/number of prey) has been highest early in the spring and pinnipeds appear effective at capturing prey even at relatively low prey density.

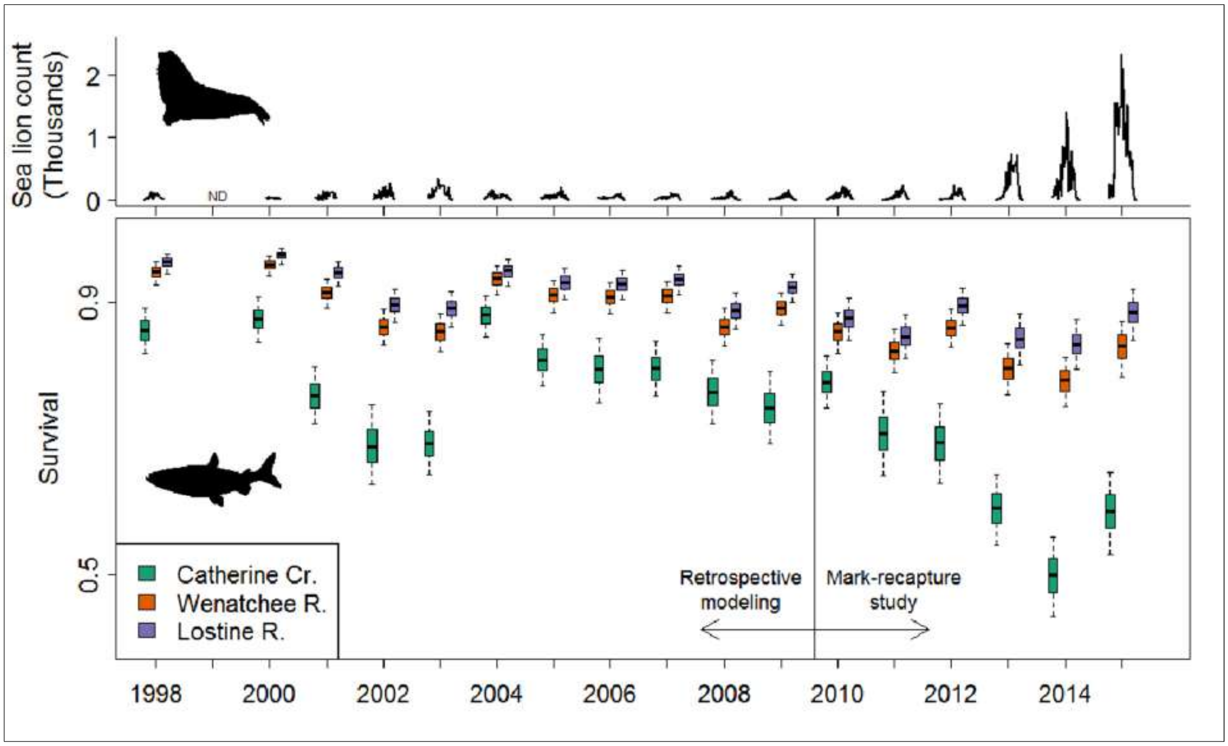

Figure 2.6-6. Daily counts of California sea lions hauled out at the East Mooring Basin in Astoria from 1 January to 30 June of 1998–2015. Sea lion counts were unavailable for 1999. Bottom Panel: Modeled population- and year-specific survival rates of adult spring/summer Chinook salmon (only the Wenatchee River population is from the UCR spring-run Chinook salmon ESU) during their migration from the mouth of the Columbia River (near Astoria) to Bonneville Dam. The boxplots represent medians, interquartile ranges, and 5th and 95th percentiles of survival rate estimates. We used the model of survival based on the mark-recapture study conducted in 2010–2015 to retrospectively model survival rates as a function of California sea lion counts (Sorel et al. 2017).

At the population level, later migrating spring-run Chinook salmon from the Methow and Wenatchee River populations are at relatively low risk of pinniped predation compared to the earlier migrating Entiat River population (Figure 2.6-7).

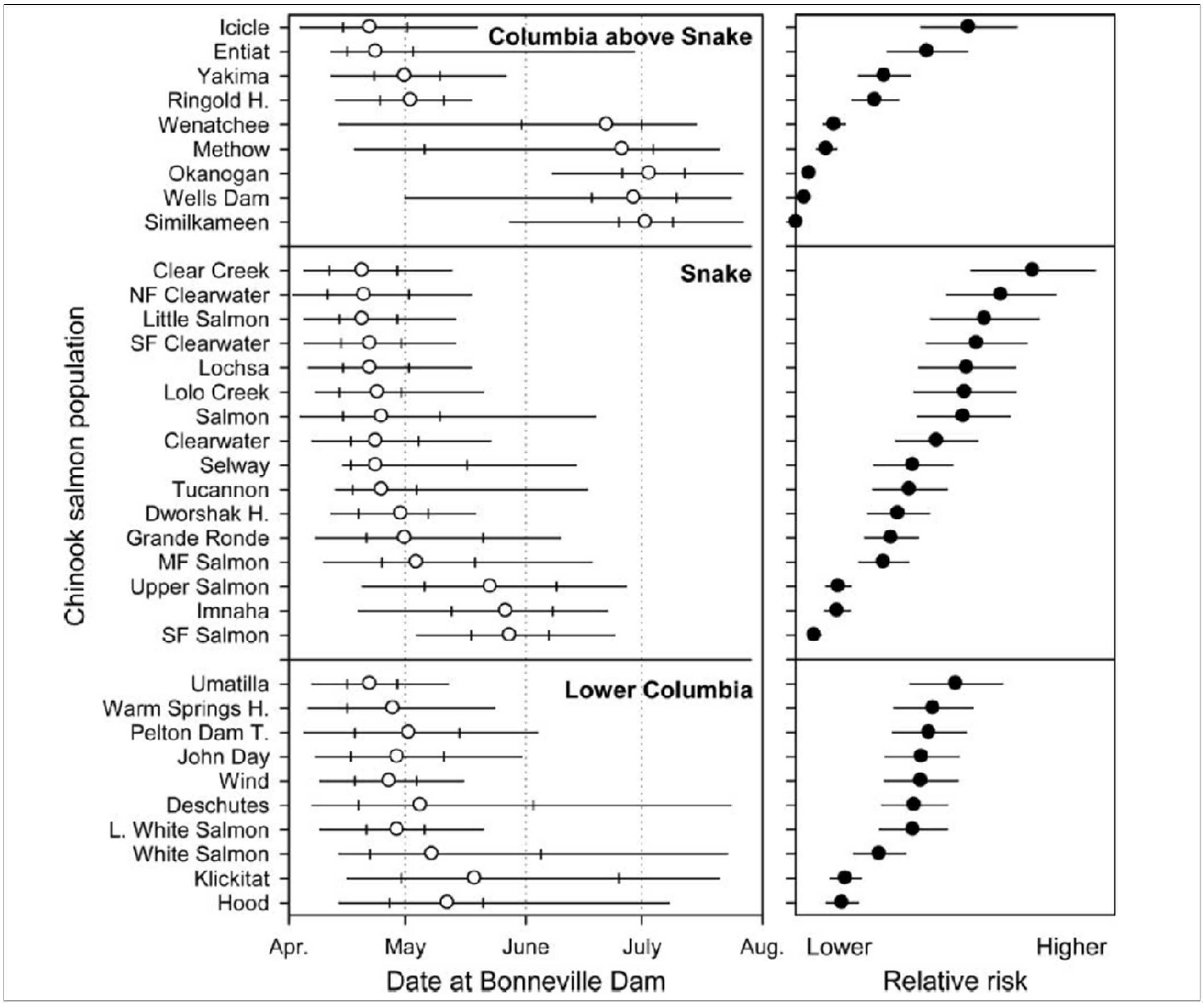

Figure 2.6-7. Left panel: Migration timing distributions calculated using 5,229 radio-tagged spring and summer Chinook salmon from 32 upriver populations in the lower Columbia River, Snake River, and Columbia River upstream from the Snake River confluence, 1996–1998 and 2000–2004. Distributions show 5th, 25th, 50th, 75th, and 95th percentiles. Right panel: the relative risk (±1 SE) of predation by pinnipeds, estimated by multiplying weekly mean predation rate estimates from the pinniped observation study by population-specific migration timing distributions.

UCR spring-run Chinook salmon losses due to pinniped predation are greatest directly downstream of Bonneville Dam; up to 50 percent of the mortality of adult spring-run Chinook salmon occurred within the 10-mile reach just below the dam (Rub et al. 2018). The dam structure provides an advantage to pinnipeds because adult fish congregate in a restricted area in search of ladder entrances (Stansell 2004).

Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019 respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between river mile 112 and McNary Dam (river mile 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

Biologists have been estimating spring Chinook salmon consumption by pinnipeds directly below (2 km) Bonneville Dam since 2002. Pinniped presence and predation in the Bonneville tailrace generally increased from 2002 to a peak in 2015, but declined substantially in the spring of 2019. Tidwell et al. (2020) report that an estimated 1,974 spring Chinook salmon (all ESUs) were consumed by both pinniped species in 2019, which equates to 3.1 percent of the adult spring Chinook salmon that passed. Consumption rates of spring Chinook salmon in the last 3 years have ranged from 2.9 to 4.6 percent and have been declining since 2016, which was the highest consumption rate observed (Table 2.6-8). This reduction in spring Chinook salmon consumption is likely the result of declining numbers of pinnipeds observed in the tailrace in the spring since 2015.

Table 2.6-8. Consumption of spring Chinook salmon by pinnipeds at Bonneville Dam tailrace from January 1 through May 31, 2002 to 2019. Passage counts of Chinook salmon include both adult and jack salmon.

Year	Bonneville Dam Spring Chinook Passage	Chinook Salmon Consumption Estimate	% Run
2002	275,290	880	0.3 %
2003	210,028	2,313	1.1%
2004	179,193	3,307	1.8 %
2005	78,341	2,742	3.4 %
2006	99,366	2,580	2.5 %
2007	83,252	3,403	3.9 %
2008	143,139	4,501	3.0 %
2009	181,174	4,360	2.3 %
2010	257,036	5,909	2.2 %
2011	218,092	3,634	1.6 %
2012	165,681	1,959	1.2 %
2013	117,165	2,710	2.3 %
2014	214,177	4,576	2.1 %

Year	Bonneville Dam Spring Chinook Passage	Chinook Salmon Consumption Estimate	% Run
2015	233,794	10,622	4.3 %
2016	148,357	9,222	5.9 %
2017	101,734	4,951	4.6 %
2018	94,350	2,813	2.9 %
2019	61,385	1,974	3.1 %

2.6.2.7 Research, Monitoring, and Evaluation Activities

The primary effects of past and present CRS-related RME programs on UCR spring-run Chinook salmon are associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were UCR spring-run Chinook salmon. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the UCR spring-run Chinook salmon ESU by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of UCR spring-run Chinook salmon that have been handled (or have died) each year using the average annual take reported from 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of UCR spring-run Chinook salmon associated with the Smolt Monitoring Program and the CSS were as follows:
    - Zero hatchery adults and zero natural-origin adults were handled.
    - Zero hatchery and zero natural-origin adults died.
    - 967 hatchery juveniles and 1,061 natural-origin juveniles were handled.
    - Two hatchery juveniles and three natural-origin juveniles died.
- Average annual estimates for handling and mortality of UCR spring-run Chinook salmon associated with other RME activities were as follows:
    - Two hatchery adults and two natural-origin adults were handled.
    - Zero hatchery adults and zero natural-origin adults died.
    - 1,267 hatchery juveniles and 5,553 natural-origin juveniles were handled.
    - One hatchery juvenile and 57 natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) of UCR spring-run Chinook salmon associated with these elements of the RME program has, on average, affected 0.06 percent of the natural-origin portion of the adult run (recent, 5-year average arriving at mouth of

Columbia River) and 1.33 percent of the (recent, 5-year average) of the naturally produced juveniles (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects UCR spring-run Chinook salmon.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the ESU level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions, which are key components of effective adaptive management programs.

2.6.2.8 Critical Habitat

The condition of UCR spring-run Chinook salmon critical habitat in the action area without the consequences caused by the proposed action, is reflected in the impacts on the PBFs essential for conservation discussed above and summarized in Table 2.6-9, below. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use and water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity. As a result, the important watershed processes and functions that once created healthy ecosystems for spring-run Chinook salmon production have been weakened. Conditions in the hydrosystem reach were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for UCR spring-run Chinook salmon have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.6-9. Physical and biological features (PBFs) of designated critical habitat for UCR spring-run Chinook salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater spawning sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for all populations. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning sites for all populations. Diminished stream flow (water withdrawals, drought) has reduced the quantity and quality of freshwater spawning sites for all populations. Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced the quality of freshwater spawning sites for all populations. Many tributary habitat improvement actions implemented in the upper Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to freshwater spawning sites.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, natural cover.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater rearing sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced the quality of freshwater rearing sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations. Excessive sediment in streambeds (forest and agricultural practices) has reduced the quality of freshwater rearing sites for all populations. Many tributary habitat improvement actions implemented in the Upper Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to freshwater

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		rearing sites.
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity and natural cover	*Effects in the migration corridors apply to all populations of UCR spring-run Chinook salmon:* Alteration of the seasonal flow regime in the Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderately negative effect in lower flow years. Alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring, when juvenile and adult UCR spring-run Chinook salmon are migrating, and warmer temperatures in late summer and fall (hydrosystem development and operations).[1] Cooler spring temperatures do not adversely affect the functioning of the mainstem as a migration corridor for juvenile or adult UCR spring-run Chinook salmon. Reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume (hydrosystem development), may have reduced "natural cover" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining). The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable lubricants" where feasible. Delay and mortality of some juveniles and adults at up to five PUD-owned and four CRS dams on the mainstem Columbia River has increased obstructions in the migration corridor. Increased exposure of juveniles to TDG in the lower Columbia River and at least 35 miles below Bonneville Dam during involuntary[2] and flexible spring spill (hydrosystem development and operations) has reduced

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		water quality in the juvenile and adult migration corridors. The incidence of adverse effects (GBT in juveniles and adults) appears to have been small (1 to 2 percent) in recent years with TDG up to 125 percent. The operation of the hydrosystem has increased obstructions by creating conditions that delay and injure/kill some juveniles and a smaller proportion of adults in the migration corridor. However, the functioning of the migration corridor has increased substantially for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult spring-run Chinook salmon during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past the dams or overwintering within the fish facilities or turbine units). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile spring-run Chinook salmon because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems). Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for avian and fish predators in the tailraces of mainstem dams. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, propane cannons, and limited amounts of lethal take. Fish predation is addressed by dam angling at several dams. Delays of adults at the ladder entrances at Bonneville Dam has increased the risk of pinniped predation (excessive predation related to hydrosystem development and

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		operation) in the migration corridor. Pinniped predation is addressed by the use of sea lion excluder devices and hazing at the fishway entrances at Bonneville Dam.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity and salinity, natural cover, juvenile and adult forage.	*Effects in estuarine areas apply to all populations of UCR spring-run Chinook salmon:* Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling Chinook salmon by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the Caspian Tern Management Plan on East Sand Island is reducing excessive predation in the estuary, but depending on ocean conditions and compensatory effects, may not be increasing adult returns for UCR spring-run Chinook salmon. Implementation of the Double-crested cormorant Management Plan may have contributed to, or at least coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island.
Nearshore marine areas[3]	Free of obstruction and excessive predation with water quality, quantity and forage.	*Effects in estuarine areas apply to all populations of UCR spring-run Chinook salmon:* Concerns about increased pinniped predation and adequate forage.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Spill is characterized as “involuntary” when water is spilled over a dam’s spillway because it cannot be stored in a reservoir behind the dam or passed through turbines to generate electricity, such as during maintenance activities, periods of low energy demand, or periods of high river flow. Involuntary spill is most common in the spring.

[3] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Habitat quality in tributary streams in the upper Columbia portion of the interior Columbia Recovery Domain varies from good in higher elevation stream reaches to degraded in lower elevation reaches, especially near valley bottoms. These areas are subject to heavy agricultural and urban development. Human activities that have contributed to these factors include dams, water diversions, stream channelization and diking, roads and railways, timber harvest, grazing, and urban and rural development (UCSRB 2015). Natural disturbances that have had a large effect on habitat include wildfires, with subsequent effects on runoff and sedimentation in areas used for spawning and rearing.

Many tributary stream reaches designated as critical habitat are listed on Oregon and Washington’s Clean Water Act Section 303(d) lists for water temperature. Areas that were historically suitable spawning and rearing habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, withdrawal of water for agricultural or municipal use, and periodic droughts have all contributed to elevated stream temperatures. Furthermore, contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016d). They can negatively impact critical habitat and the organisms associated with these areas.

The general effects of mainstem and tributary dams on the functioning of critical habitat for UCR spring-run Chinook salmon are:

- Lost access to historical spawning areas behind tributary dams built without fish passage facilities (obstructions).
- Altered juvenile and adult passage survival at dams with passage facilities (obstructions).
- Altered flows and seasonal timing (reduced water quantity).
- Altered seasonal temperatures and elevated dissolved gas (reduced water quality).
- Reduced sediment transport and turbidity (reduced water quality).
- Altered food webs, including both predators and prey (reduced prey production and increased numbers of predators, including non-natives).

Habitat quality of migratory corridors in this area was substantially affected by the development and operation of the CRS dams and reservoirs in the mainstem lower Snake and Columbia Rivers, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and upper Columbia River basins. Hydrosystem development modified natural flow regimes, resulting in warmer late summer/fall water temperatures. Changes in fish communities led to increased rates of piscivorous predation on juvenile salmon and steelhead. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines and juvenile bypass systems, have also killed out-migrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented measures in the juvenile and adult migration corridor including 24-hour volitional spill, surface passage routes, upgrades to juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

In addition, basinwide water management activities, including the operation of the CRS water storage projects for flood control, power generation, and water withdrawals have substantially reduced average monthly flows at Bonneville Dam during May to July and increased them during October to March compared to an unregulated system. Reduced spring flows, combined with the existence of mainstem dams, increased travel times during the juvenile outmigration period for UCR spring-run Chinook salmon, increasing the risk of predation. Since salmon and steelhead were listed and critical habitat was designated under the ESA, the Action Agencies have made substantial changes to minimize these operational effects by limiting storage reservoir elevations to minimums needed for flood risk management and passing more water during the spring refill period. By taking these actions, the Action Agencies have increased flows in the spring and summer, which helps replicate the natural hydrograph. As a result, the functioning of the migration corridor has been improved by reduced exposure to predators, increased turbidity (which can provide visual cover), and increased access to cover and prey in nearshore mainstem habitat.

The functioning of juvenile rearing and migration habitat for UCR spring-run Chinook salmon in the lower Columbia River estuary has been reduced by the conversion of more than 70 percent of the original marshes and spruce swamps to industrial, transportation, recreational, agricultural, or urban uses. Water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. Reduced sediment delivery to the lower river and estuary, combined with in-water structures that focus flow in the navigation channel and bank armoring, have altered the development of habitat along the margins of the river. All of these changes have reduced the availability of prey for smolts between Bonneville Dam and ocean entry.

In the hydrosystem reach, altered habitats in project reservoirs and tailraces create more favorable habitat conditions for fish predators; the latter include native northern pikeminnow and non-native walleye and smallmouth bass. The effects of the non-native species and those of pikeminnow, to the extent they are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea-lion predation on adult UCR spring-run Chinook salmon in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary has increased, but is a natural phenomenon and therefore not excessive predation in the context of effects on the functioning of critical habitat.

Restoration activities in tributary spawning and rearing areas and in the estuary that are addressing habitat quality and complexity, and improved functioning of the juvenile migration corridor (e.g., 24-hour and flexible spill, new surface passage structures, and improved spillway designs) have improved the baseline condition for some components of the PBFs. However, more restoration is needed before the PBFs can fully support the conservation of UCR spring-run Chinook salmon.

2.6.2.9 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. NMFS' most recent 5-year review evaluated new information regarding the status and trends of UCR spring-run Chinook salmon, including recent biological opinions issued for actions likely to affect the UCR spring-run Chinook salmon ESU and key emergent or ongoing habitat concerns (NMFS 2016d). From January 2015 through May 22, 2020, we completed 418 formal consultations that addressed effects to UCR spring-run Chinook salmon.[228] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species) such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat, improve riparian conditions, and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

[228] PCTS data query July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.6.2.10 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of UCR spring-run Chinook salmon populations. Recent improvements in passage conditions at mainstem FERC licensed and CRS dams, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, tributary habitat improvements, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. The recovery plan identified habitat degradation, hydropower systems, harvest, hatcheries, and changes in estuarine habitat, climate change, inadequacy of regulatory mechanisms, fluctuating ocean cycles, and predation as limiting factors that continue to negatively affect UCR spring-run Chinook salmon populations (UCSRB 2007).

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for UCR spring-run Chinook salmon, as described above. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of these critical habitat PBFs. For example, surface passage structures and spill operations have reduced obstructions for juvenile UCR spring-run Chinook salmon at CRS dams in the lower Columbia River. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. Similarly, projects that have protected or restored tributary habitat have improved the functioning of the freshwater spawning and rearing sites. However, the factors described above continue to have negative effects on these PBFs.

2.6.3 Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020; Section 2).

2.6.3.1 Effects to Species

2.6.3.1.1 Spill and Seasonal Flow Operations

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams. The intent of flexible spill operations is to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem.[229] Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG spill ("gas cap spill") for a minimum of 16 hours per day, and each project may operate under lower spill levels ("performance standard spill") for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill at all hours. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs maximum spill constraint) for 16 hours per day with 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan, unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in performance standard spill periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.6-10.

[229] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

Table 2.6-10. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.6-11. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.6-11. Target summer spill levels at lower Columbia River projects as described in the proposed action (BPA et al. 2020).

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
McNary	57% (with no spillway weirs)	20 kcfs

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[2]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March, decreased flows from May through August, and little change in flows in April and September) described in the Environmental Baseline section will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in all project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce high TDG events associated with spill in the winter, which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. The proportional effect on flow is higher in the lower Snake River than in the lower Columbia River due to its smaller flow volume. Nonetheless these flow changes do transfer into the lower Columbia River and have the potential to affect UCR spring-run Chinook salmon in the lower Columbia River. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.6-8).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

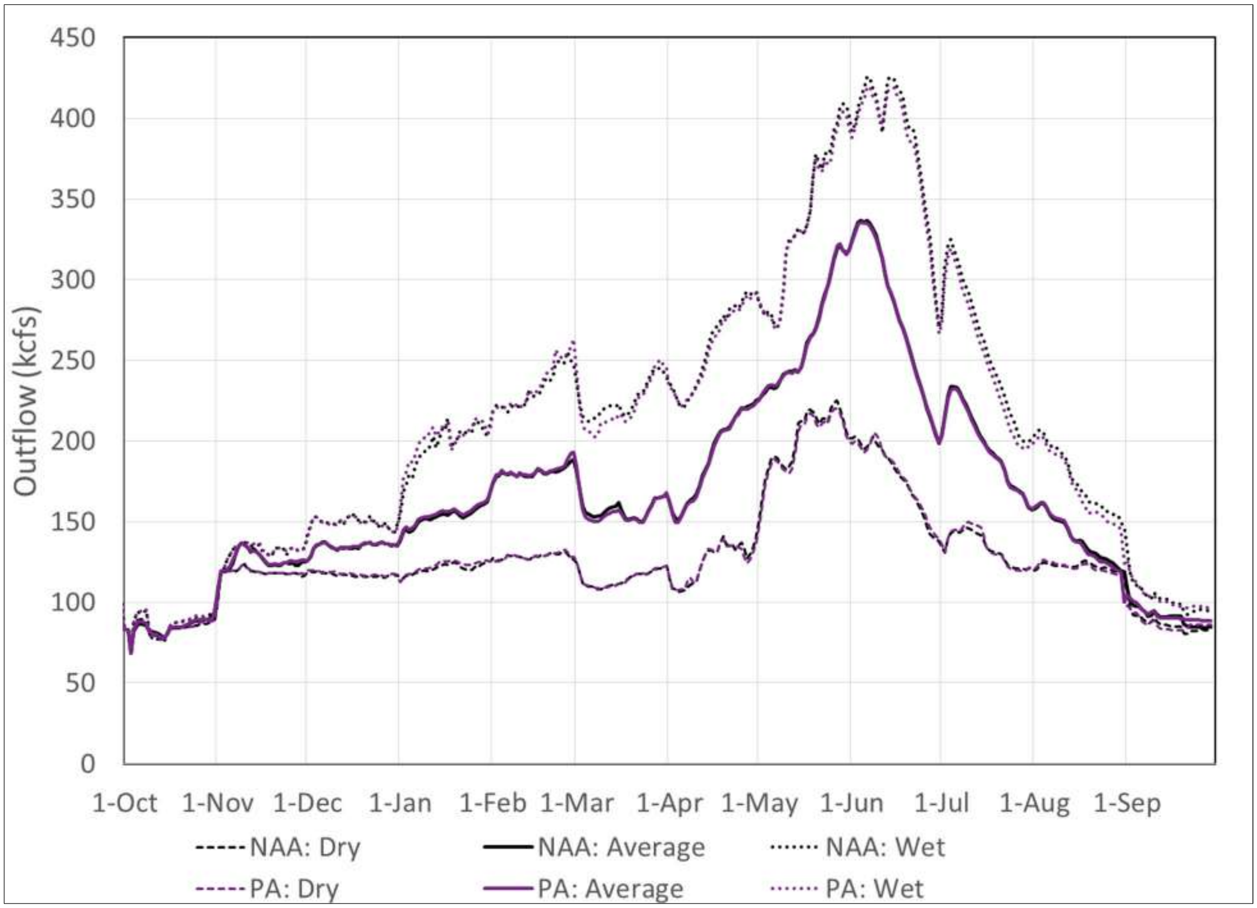

Figure 2.6-8. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

Juvenile UCR spring-run Chinook salmon migrate through the lower Columbia River primarily in May to early June, and the Action Agencies will operate to meet seasonal flow objectives to support juvenile migrants during that period. Adult UCR spring-run Chinook salmon migrate primarily in April to July. The proposed change in flow would be too small to affect river temperature during the adult migration period, which would be the attribute of highest concern. The associated effects on UCR spring-run Chinook salmon smolts or adults should not change from recent conditions by a meaningful amount.

The effects of the proposed hydrosystem operations and the non-operational measures on UCR spring-run Chinook salmon and its habitat are described below.

2.6.3.1.2 Water Quality

The operation of the CRS will continue to affect water quality parameters in the mainstem migration corridor. This includes delayed spring warming, delayed fall cooling, and reduced temperature variability on a daily basis due to some of the thermal inertia of the reservoirs.

Taken together, the proposed measures at Grand Coulee Dam would influence reservoir elevations at Lake Roosevelt; however, effects on water temperature would be negligible. At Chief Joseph Dam, monthly outflows are predicted to be similar to or about 1 percent less for all types of water years, and tailrace temperatures are expected to be similar to existing conditions. Tailrace temperatures should not be measurably altered by the proposed action and are predicted to continue to exceed the Washington State water quality standard for August and September (7-day average of the daily maximum temperature of 63.5°F). There will be little difference in temperature between Grand Coulee Dam and Chief Joseph Dam, showing that water temperatures below Lake Roosevelt are unchanged through Rufus Woods Lake (USACE et al. 2020).

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacity spill. These events occur most frequently in May and June but may also occur in other months.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spill operation (up 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from McNary Reservoir near the confluence with the Snake River to at least 35 miles downstream of Bonneville Dam. Individuals from all "upstream" populations and MPGs would be exposed to a greater extent than those from "downstream" populations and MPGs. Smolts typically migrate at depths that effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020). Data from all fish sampled in the CRS Gas Bubble Trauma Monitoring Program (1996 to 2019) indicate that signs of GBT were almost non-existent below 120 percent TDG, increased slightly between 121 percent and 125 percent TDG, and then increased in incidence and severity when TDG levels exceeded 125 percent (FPC 2019). The available information in Zabel (2019) and Widener et al. (2020) suggests that the relatively high TDG exposure often exceeding 125 percent during high flow years (e.g., 2006 and 2011) did not reduce smolt survival through the CRS. Thus, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable based on reach survival studies) increase in mortality of juvenile UCR spring-run Chinook salmon.

Adult UCR spring-run Chinook salmon typically migrate between Bonneville and Priest Rapids Dam during the period when the flexible spill operation would occur (April through June). Adults also migrate at depths that reduce the effective exposure to TDG through depth compensation mechanisms. Thus, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[230] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on UCR spring-run Chinook salmon are likely to be very small and are not expected to detectably affect reach survival estimates.

Sediment Transport

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency hypothetically increases the exposure of UCR spring-run Chinook salmon juveniles to predators (Gregory 1993, Gregory and Levings 1998,

[230] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

Sontag 2013) and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile UCR spring-run Chinook salmon spend days to weeks in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

2.6.3.1.3 Project Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems (BPA et al. 2020). Maintenance activities evaluated and covered under this opinion can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance, as summarized in Section 1.3 of this opinion and in further detail in BPA et al. (2020).

Fishway structures (e.g., fish ladders, screens, bypass systems) will be routinely maintained and temporarily removed from service on a scheduled basis during the established in-water work period (December to March), in accordance with the Fish Passage Plan and coordinated through FPOM to minimize impacts to adult and juvenile migrants. At Bonneville Dam, routine dredging in the forebay and rock removal in the spillway will occur every year or two to ensure reliable operation and structural integrity of the fishways. Turbine unit maintenance is planned at all dams and will be coordinated through FPOM to minimize and avoid delay, injury, and mortality.

Routine outages of fishways are necessary to maintain reliability, but these temporary outages can cause delay and mortality for adult and juvenile migrants that attempt to migrate at the time of the outage. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be very few, or relatively low numbers of, UCR spring-run Chinook salmon that are migrating, and these effects will occur at extremely low levels similar to what was observed in the recent past. Passage delay and conversion rates will be monitored and maintenance schedules may be modified through FPOM or adaptive management if evidence indicates elevated delay and mortality are occurring.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization and major rehabilitations. At McNary Dam, turbine replacement is expected to begin within the next 15 years. At John Day Dam, turbine replacement may begin, but it is uncertain at this time if it will be completed, within the 15-year period of the proposed action. The proposed maintenance at Grand Coulee could result in outages and additional spill in limited situations, but changes to total outflows are not expected. Non-routine maintenance (related to turbines or spillbays) expected in the proposed action can increase TDG during uncontrolled spill by temporarily reducing powerhouse capacity and may cause suboptimal tailrace conditions which can delay passage. The installation of improved fish passage turbines will likely improve turbine survival and reliability once completed. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce risk to adults and juveniles.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated with NMFS and through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize negative effects on fish. Fish passage metrics will be monitored with counts and PIT tags to ensure unscheduled maintenance activities do not result in negative impacts to the ESU.

Overall, scheduled maintenance activities are expected to continue to negatively affect only small numbers of adult and juvenile UCR spring-run Chinook salmon annually because they are not typically migrating during the period of time when these activities are typically scheduled. The impact of unscheduled maintenance on juvenile and adult UCR spring-run Chinook salmon will likely continue to result in increased TDG exposure, passage delay, and occasional mortalities during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes will continue to minimize the impacts.

2.6.3.1.4 Adult Migration/Survival

Adult survival rates for UCR spring-run Chinook salmon are expected to continue to average about 90.8 percent (2010 to 2019 average) from Bonneville to McNary Dams under the proposed action. Tailrace conditions at John Day Dam during low to moderate flows could be degraded by the increased spill levels (16 hours per day) resulting from the flexible spring spill operation during the spring spill period. While this operation could negatively affect passage conditions for migrating adults (i.e., the ability to find fishway entrances), 8 hours of performance level spill should be sufficient to prevent any measurable impacts to passage or adult survival. The flexible spill operations should not negatively affect passage conditions for UCR spring-run Chinook salmon at the other lower Columbia River dams. It is also possible that fallback rates—which are associated at many dams with higher spill levels—will increase slightly at the lower mainstem dams (except The Dalles Dam). Adult fallback has been associated with longer migration times and reduced survival rates. However, the additional fallback would most likely happen through a spillbay (rather than a turbine unit or screened bypass system), which would be expected to increase the survival of these fish, relative to the other passage routes (Colotello et al. 2013, Normandeau et al. 2014). This would potentially offset some of the potential impact of increased fallback rates associated with increased spill levels under the proposed action. Adaptive management processes can be used to identify (daily or weekly estimates of fallback and reascension rates) and remedy (through in-season management processes) excessive fallback or migration delays, if it occurs.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. This change would affect very small numbers of adult UCR spring-run Chinook salmon that may still be migrating after that date in August by improving adult ladder attraction conditions and reducing fallback rates. However, individuals that fell back would experience greater risk because they would be more likely to pass via turbines and juvenile bypass systems instead of the spillway. Very few adult UCR spring-run Chinook salmon are expected to be migrating when this occurs, so this is not expected to have a measurable impact on survival rates.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14, unless adjusted due to (rare) low flow occurrences in the Snake River to meet authorized project purposes. Maintaining the increased operating range by 6 inches at the lower Snake River dams (MOP 1.5-foot range) as implemented in 2019 and 2020 has not yet been fully evaluated under a range of flow years. The increase in operation range is expected to slightly reduce the average flow rate in the reservoirs, but the flow change is minimal and is not expected to affect adult survival rates of UCR spring-run Chinook salmon since it will occur outside of their migration corridor, and only a few strays might experience this flow condition.

The Action Agencies propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP (262.5 to 264.5 feet), except during the spring spill period, when the John Day forebay operating elevation window will be increased. From April 10 to June 1 to 15, the elevation at John Day Reservoir will be held between 264.5 feet and 266.5 feet to deter piscivorous Caspian terns from nesting in the Blalock Islands Complex (see Section 2.2.3.1.10). Following this operation, the reservoir's elevation would return to MIP + 2 feet operation through August 31. The increase in operating range is expected to slightly reduce velocities in John Day Reservoir, but the velocity change is not expected to affect adult migration timing or survival rates.

Power generation at Snake River projects may cease between 2300 and 0500 hours from October 15 to February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. PIT-tag data indicate that very few adult UCR spring-run Chinook salmon will migrate through the Snake River during this operation, so we expect no effect on adult migration timing or survival for this ESU.

The proposed operations at Libby Dam, Hungry Horse Dam, and Grand Coulee Dam should not measurably affect adult migration or survival because the flow alterations in the Columbia River are relatively small (less than 2 kcfs measured at Bonneville Dam during the months when these fish migrate. The small reduction of flow would not be sufficient to affect river temperature, which would be the most relevant effect influencing adult migration success. The proposed operation at Dworshak Dam is not expected to affect migrating UCR spring-run Chinook salmon adults because it occurs only during high flow years and is outside of their migration corridor.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for adult salmonids passing through the turbine units, but the number of adults affected should be extremely low because of the short time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG could reduce TDG exposure and improve ladder attraction conditions for adult UCR spring-run Chinook salmon, but would also slightly reduce turbine unit survival for adult salmonids passing through the turbine units. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams from April through June. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. Overall adult survival rates of UCR spring-run

Chinook salmon between Bonneville Dam and McNary Dam should not be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

2.6.3.1.5 Juvenile Migration/Survival

The Action Agencies propose to continue to provide fish passage spill (conventional and surface passage), operate juvenile bypass systems, and implement other operations (e.g., ice and trash sluiceways, Bonneville corner collector, etc.) for juvenile passage at the four lower Columbia River dams. Surface passage structures exist at all four lower Columbia dams, and three of them have juvenile bypass systems. The Dalles Dam does not have a juvenile bypass system because of low powerhouse passage rates. Increased spill levels resulting from the flexible spring spill operation are expected to have little negative effect on tailrace conditions at Bonneville or McNary Dams, but could cause eddies to form at John Day Dam under lower flow conditions. The latter would likely increase the exposure to predators of juvenile Chinook salmon passing through the spillway, thereby reducing spillway survival by a small, but unknown amount. Increased spill levels at three of the four lower Columbia River mainstem dams (The Dalles Dam operation will continue spilling at 40 percent) would generally be expected to slightly increase direct dam passage survival rates of inriver migrating smolts as spillway survival rates generally exceed those in the juvenile bypass systems or through the turbine units. Overall, the survival of inriver migrating juvenile UCR spring-run Chinook salmon from all populations should increase slightly as a result of implementing the flexible spring spill levels at the four lower Columbia River dams. Increases in downstream migration survival are expected to increase population productivity by delivering more smolts to the ocean, resulting in more adults returning.

The proposed operations at Libby Dam, Hungry Horse Dam, Grand Coulee Dam, and Dworshak Dam will alter flows by less than 2 percent during the spring migration period. This would be expected to result in very small increases in travel times in April and May, and small decreases in travel times in June, but should not measurably affect juvenile survival. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

Spill reduction starting in August (15 to 31) would not affect juvenile UCR spring-run Chinook salmon, which migrate in the spring. The Action Agencies proposal to operate the lower Snake River Dams at MOP with a 1.5-foot operating range from April 3 until August 14 will not impact travel time or survival for juvenile UCR spring-run Chinook salmon migrating in the Columbia River.

The Action Agencies also propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP level (262.5 to 264.5 feet), except during the spring spill period, when the John Day forebay operating range will be increased. From April 10 to June 1–15, the elevation of John Day Reservoir will be held between 264.5 feet and 266.5 feet to deter Caspian terns from nesting in the Blalock Islands Complex (Section 2.2.3.1.10). Following this operation, the elevation of John Day Reservoir would return to MIP +2 feet operation through August 31. The increase in operation range is expected to reduce the flow rate in John Day Reservoir, increasing travel time for juvenile UCR spring-run Chinook salmon compared to the recent average.

Power generation at Snake River projects may cease for short periods between October 15 and February 28 and will result in no flow past the Snake River during these periods. Because they are not present in the Snake River, no UCR spring-run Chinook salmon juveniles migrating in the Columbia River will be measurably impacted by this operation. As described above (see Section 2.6.3.1.4), under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, but the number of juveniles affected should be extremely low because of the limited time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure, would slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, and would slightly increase powerhouse passage rates of juvenile UCR spring-run Chinook salmon. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units and increase powerhouse passage rates.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of UCR spring-run Chinook salmon between Bonneville Dam and McNary Dam, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

COMPASS Model Results

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT tags (detection efficiencies and project and reach survival estimates) and acoustic tags (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model.

For UCR spring-run Chinook salmon, COMPASS estimates that the increased spill levels at the lower Columbia River dams resulting from the proposed action (flexible spill up to 125 percent TDG) and increased pool elevation at John Day Dam:

- Average travel times from McNary tailrace to Bonneville tailrace of 5.54 days.
- Average juvenile survival from McNary tailrace to Bonneville tailrace of 70.8 percent.
- Average juvenile survival from Rock Island tailrace to Bonneville tailrace, a reach that includes McNary pool, of 51.0 percent.
- Average number of spill passage events (the inverse of the CSS's PITPH metric) of 4.04 for the seven dams traversed (RIS to BON).

The Draft EIS used COMPASS to compare the Preferred Alternative (proposed action) to the No Action Alternative (2016 Operations) (USACE et al. 2020). The median model results (USACE et al. 2020, Tables 7 to 21) indicated that the flexible spring spill operations (proposed action), compared to the No Action Alternative, would:

- Reduce juvenile travel times from McNary to Bonneville Dam by about 0.5 days.
- Increase juvenile survival from McNary to Bonneville Dam by about 1 percent.
- Increase the number of spillway passage events from Rock Island to Bonneville Dam by about 0.33.

These results support our qualitative expectations that juvenile survival rates for UCR spring-run Chinook salmon in the lower Columbia River would not change in biologically significant ways (i.e., enough to affect the abundance or productivity of any UCR spring-run Chinook salmon population) as a result of the proposed operation. The CSS hypothesizes that flexible spring spill would reduce latent mortality by reducing the number of powerhouse (turbine unit or juvenile bypass system) encounters for Snake River spring Chinook salmon. If this proves to be true for UCR spring-run Chinook salmon as well, an additional small improvement in adult returns may occur. However, another possible explanation for reduced return probabilities of bypassed fish is that smaller fish and those in poorer condition tend to enter bypass systems with higher probability (Zabel et al. 2005, ISAB 2012, Hostetter et al. 2015, Faulkner et al. 2019), and smaller fish and fish in poorer condition also have lower return probability (Ward and Slaney 1988, Zabel and Williams 2002, Evans et al. 2014). This suggests that the apparent effects of juvenile bypasses on juvenile survival and adult return probability are due, at least in part, to the correlation between bypass probability and fish size and condition, and not due to bypass passage itself. Thus, increasing spill levels will incrementally increase the proportion of spillway passed fish and reduce travel times and could, assuming spillway passage survival rates are not substantially reduced as a result of poor egress and tailrace conditions, improve direct juvenile survival rates. But increasing spill levels might not increase adult returns to the extent hypothesized by the CSS. It is also important to note that since higher spill levels result in degraded tailrace conditions, juvenile survival could be lower than COMPASS predicts as a result of extended tailrace delay and the potential for predation at some projects.

2.6.3.1.6 Transportation

Consistent with current practices, no UCR spring-run Chinook smolts will be transported as a result of the proposed action. Any changes to transportation operations in 2020 would not affect UCR spring-run Chinook because juveniles only migrate downstream of the lower Snake River collector projects.

2.6.3.1.7 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program’s goals are to increase the extent and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to UCR spring-run Chinook salmon as they migrate through the estuary.

NMFS agrees with the ISAB’s assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies’ proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty about predicting the availability of habitat restoration actions into the future and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and be initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the action effectiveness monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program either will confirm that these floodplain reconnections are enhancing conditions for salmonids such as UCR spring-run Chinook salmon as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the

Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change considerations and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management, which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the influx of insect and amphipod prey to the mainstem migration corridor for juvenile UCR spring-run Chinook salmon. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[231] of all UCR spring-run Chinook salmon populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.6.3.1.8 Tributary Habitat

For the UCR spring-run Chinook salmon ESU, the Action Agencies will implement tributary habitat improvements to achieve the metrics outlined in Table 2.6-12 for the single MPG in the ESU. Actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations, and will accomplish specific metrics defined for the single MPG (BPA et al. 2020).

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[231] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile Chinook salmon opportunities to move into wetland habitats for food and refuge from predators. Moreover the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the UCR spring-run Chinook salmon ESU.

Table 2.6-12. Proposed tributary habitat metrics (2021–2036) for the single major population group in the UCR spring-run Chinook salmon ESU (BPA et al. 2020).

Upper Columbia River Spring Chinook Salmon ESU Major Population Group[1]	Metrics					
	Flow Protected (cfs)	Flow Enhanced (acre-feet)	Entrainment Screening (# screens)	Habitat Access (miles)	Stream Complexity (miles)	Riparian Habitat Improved (acres)
North Cascades MPG	64	11,946	8	9	25	205

[1] The habitat actions that produce these metrics will be completed or in process by the end of 2036.

To develop these metrics, the Action Agencies reviewed implementation under the 2008 and 2019 biological opinions and developed metrics assuming a consistent level of effort for tributary habitat implementation. In addition, the Action Agencies have committed to continuing to improve the strategic implementation of the program, to implement the program with input from the Tributary Habitat Steering Committee that was convened under the 2019 biological opinion, to convene a Tributary Technical Team to provide input to program implementation, to report on implementation using metrics that will allow NMFS to evaluate implementation of the program, to undertake comprehensive program reviews every 5 years to evaluate how to enhance benefits from the program, and to conduct RME to assess tributary habitat conditions, limiting factors, and action effectiveness, and to inform our understanding of critical uncertainties (BPA et al. 2020).

As part of the adaptive management program, the Action Agencies, with input from the THSC and TTT, will reevaluate implementation at 5-year intervals (see Appendix D of BPA et al. 2020). The proposed metrics after the first 5-year period may be adaptively managed, based on input from the THSC and TTT, to optimize fish benefits based on understanding of species status and population priorities, limiting factors, what actions will provide the greatest benefits, implementation considerations, etc.

For an overview of how NMFS analyzed the effects of tributary habitat improvement actions for this opinion, see Appendix A. In brief, we reviewed and reaffirmed the strong technical foundation for the tributary habitat program (i.e., that strategically implementing actions to alleviate the factors that limit the function of tributary habitat will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead). We evaluated new RME information and found that it also supported the foundation of the program. We determined that the methods we were using to evaluate the effects of tributary habitat actions were based on best available science, as described in the Appendix A. We evaluated the effects of those actions quantitatively for some populations and qualitatively for all populations within the context of our understanding of limiting factors, the effects of the types of habitat improvement actions being proposed, population extinction risk, habitat improvement potential, and our recovery plan framework. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered certainty of implementation and effects, as well as the strategic framework within which the Action Agencies were committing to implement the program. In addition, we considered the adequacy of the RME and adaptive management framework that is proposed to guide and refine implementation of the habitat improvement actions and inform our understanding of their effects, and the adequacy of the proposed reporting on actions implemented.

For this ESU, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, to improve access to habitat, to improve stream complexity, to improve riparian habitat, and to reduce entrainment. Limiting factors in this MPG include diminished stream flow, reduced stream complexity and channel structure, degraded riparian conditions, and habitat access (see Section 2.6.2.4), so the actions will be targeted toward addressing these identified limiting factors.[232]

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.6-13. The positive changes noted in the table below may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

Table 2.6-13. Effects and timing of effects of proposed tributary habitat improvement actions for UCR steelhead.

Action Type	Effects of action and timing of effects
Flow protection and enhancement	Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017a). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Sabaton et al. 2008, Roni et al. 2014). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and the success of these projects (Roni et al. 2008). For example, ongoing studies in the Lemhi River show increased spawner and juvenile abundance of both Chinook salmon and steelhead following enhancement of instream flows in tributaries (Uthe

[232] While unscreened diversions did not rise to the level of ESU- or population-scale synthesis of current limiting factors, it is quite possible that there are local conditions where unscreened diversions are causing significant adverse effects.

Action Type	Effects of action and timing of effects
	et al. 2017, Appendix A of Griswold and Phillips 2018). The effects of flow augmentation on habitat conditions depend on the amount of flow within the channel and how much water is added. Augmented flow in dewatered channels or streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).
Improved stream complexity	Stream complexity created by large wood, boulders, coarse substrate, undercut banks, and overhanging vegetation (in concert with adequate flow regimes and other habitat-forming processes) is an essential feature of productive salmon habitat, providing the features needed for adequate spawning and rearing. Functioning floodplains and side-channels with hydrologic connectivity are also key features of productive salmon habitat because they provide rearing, resting, and refuge habitat; increase availability of prey; and enhance other stream and watershed processes (NMFS 2013a, 2017a). Habitat improvement actions commonly implemented to enhance stream complexity include placement of large wood, boulders, and cover structures; gravel addition; floodplain reconnection; side channel and pond construction and reconnection, levee removal, and setback; channel re-meandering; and, more recently, the construction of beaver enhancement structures (Roni et al. 2014, Hillman et al. 2016). These actions can be expected to aid in reestablishment of hydrologic regimes, increase the availability of rearing habitat, improve access to rearing habitat, increase the hydrologic capacity of side channels, increase channel diversity and complexity, provide resting areas for salmonids, provide flood water attenuation, and enhance native plant communities (NMFS 2013a). The placement of instream structures includes a wide variety of actions that can affect many different habitat factors, so salmonid responses documented in the literature are quite diverse, ranging from small negative responses to large increases in abundance, growth, and survival. Most studies of this type of action indicate a positive response (increased abundance and density) for salmonids. The lack of response or decrease in abundance identified in some studies was often because the projects did not address upstream watershed processes (e.g., sediment, water quality, etc.), the actions did not address the factors limiting fish, duration of monitoring was too short to demonstrate a positive effect, or the treatments resulted in little change in physical habitat. Salmonids have also been shown to respond rapidly to reconnected or constructed floodplains, side channels, and wetlands. These habitats provide critical rearing habitat for juvenile Chinook, coho, and steelhead. Studies indicate that these actions increase salmonid abundance, individual growth rates, overwinter survival, and smolt production (Hillman et al. 2016). While benefits of actions to improve stream complexity may be rapid in terms of fish occupying restored habitats, they also will continue to accrue over some time as habitat continues to respond.
Riparian Habitat Improvement	Riparian vegetation provides numerous functions including shading, stabilizing streambanks, controlling sediments, contributing large wood, and regulating the flow of nutrients. Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014, Hillman et al. 2016, NMFS 2017a). Benefits of riparian planting actions take more than 50 years to fully accrue, although some benefits begin to accrue after 5 to 10 years (Justice et al. 2017, Pess and Jordan, eds. 2019). Few studies have examined the response of instream habitat or fish to riparian planting or thinning, in part because of the long lag time between tree growth and any change in channel conditions or delivery of large wood. However, a retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and instream anadromous fish habitat at revegetated sites. Modeling work in the Grande Ronde River basin indicates that riparian enhancement actions should reduce water temperatures and increase juvenile salmonid abundance up to 377 percent in the Upper Grande Ronde River and 61 percent in Catherine Creek (McCullough et al. 2016). Justice et al. (2017)

Action Type	Effects of action and timing of effects
	utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River and Catherine Creek basins in Oregon. They focused on streams that had been degraded by intensive land use leading to reduced riparian vegetation and widened channels and concluded that restoration of such streams could more than make up for expected increase in summer stream temperature through 2080. Studies of fish response to livestock exclusion projects have shown variable results. Some have shown increases in salmonid abundance while others have shown no response. Those showing no response were linked to short duration of monitoring, small size of enclosures, and upstream habitat processes that limited habitat conditions in the project area (Hillman et al. 2016).
Improved habitat access	Impaired fish passage can prevent adults from accessing upstream spawning habitat and impede juvenile fish migration. In addition, structures that impede fish passage can disrupt habitat-forming processes related to flow, sediment transport, and large wood (NMFS 2013a, 2017a). Improving fish passage through actions that replace, improve, or remove culverts, dams, and other migration barriers, or that provide fish passage structures, can provide access to previously inaccessible spawning and rearing habitat. In addition, removing barriers can enhance habitat-forming processes related to flow, sediment transport, and movement of large wood and contribute to improvements in stream morphology, substrate, connectivity, stream flow, and stream temperature (NMFS 2013a, Hillman et al. 2016). Studies evaluating the effectiveness of projects that have removed impassable culverts/dams or have installed fish passage structures in North America and elsewhere, including in the Columbia River basin, have consistently shown rapid colonization by fishes; some studies have also documented the physical impacts of barrier removal on sediment and channel changes (Hillman et al. 2016). The rate at which salmon and trout recolonize habitats following barrier removal is highly dependent on the amount and quality of habitat upstream of the barrier, and the size of the downstream or nearby source population (number of salmon or trout returning that could colonize) (Hillman et al. 2016).
Entrainment	Diversion of water from rivers can negatively affect salmon and steelhead populations. For example, open, unmodified water diversions can act as a source of injury or mortality to resident or migratory fishes from entrainment and impingement, and can cause habitat degradation and fragmentation. Fish-protection devices, such as exclusion screens, can physically or behaviorally deter fish from approaching or being entrained into water diversions. Most monitoring of screening projects is compliance monitoring rather than effectiveness monitoring, with a focus on whether installation or upgrading screens has reduced entrainment of fish into irrigation or water withdrawal systems. In one evaluation, however, Walters et al. (2012) conducted modeling that indicated that an extensive program to screen diversions in the Lemhi River had potentially significantly reduced mortality of outmigrating Chinook salmon smolts. Screening irrigation or water withdrawal systems and reconnecting spawning and rearing streams often provide immediate and important survival and carrying capacity benefits (Hillman et al. 2016).

All three populations in this ESU must achieve at least viable status to meet the delisting goals established in the ESA recovery plan (UCSRB 2007), and there is potential for improvement in tributary habitat productivity in all three populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the approach outlined in the proposed action (i.e., consistent with

ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced (Appendix A; also see, e.g., Hillman et al. 2016, ISAB 2018, Pess and Jordan, eds. 2019).[233]

The Action Agencies have well-developed partnerships with local implementing groups in the upper Columbia River. In the upper Columbia River, the Action Agencies, in coordination with the Upper Columbia Regional Technical Team (UCRTT), utilized the Upper Columbia Biological Strategy (UCRTT 2013) to document biological considerations for the protection and improvement of habitat, primarily in the Methow and Wenatchee Rivers, and, to a lesser degree, in the Entiat River. This strategy is the guiding document used by the UCRTT to evaluate proposed projects, and it provides a scientific basis for a formal process to design, select, and prioritize habitat improvement actions in an effort to achieve the highest biological benefit and ensure project goals are met. The UCRTT intends to update the strategy periodically as new information becomes available (see UCRTT 2017). In addition, numerous detailed reach assessments have been completed to identify sources of stream impairment, limiting factors, and specific action opportunities. This on-the-ground infrastructure, combined with the Action Agencies' commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate places.

To help assess the extent of benefits, NMFS used a life-cycle model to evaluate the effects of some types of the proposed tributary actions on the Wenatchee River spring-run Chinook salmon population (see Section 2.6.3.1.12). The proposed tributary habitat actions for 2021 to 2036 for UCR spring-run Chinook salmon include flow protection and enhancement, screening of water diversions, and actions to improve access, stream complexity, and riparian habitat. The model, however, can only assess the benefits to juvenile rearing capacity of actions to improve access and stream complexity. Because the model does not evaluate the effects of actions such as

[233] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward recovery as defined in the ESA recovery plan. NMFS' focal population concept (Cooney et al. 2020a) may inform decisions about which populations have the highest potential to benefit ESU status in the near term from directed habitat actions. However, in this case there are only three populations in the ESU, and all three are required to be at least viable to achieve recovery as defined in the ESA recovery plan. Thus, there is less utility in focusing near-term efforts on a subset of populations, and any of the three is likely an appropriate focus of near-term tributary habitat effort. Nevertheless, NMFS will work with the Action Agencies during implementation of the proposed action to evaluate opportunities for greater alignment of implementation efforts with recovery plan priorities and focal population concepts to the extent they are not currently aligned. The Action Agencies (BPA et al. 2020) indicated that initially (i.e., for the first 5-year period of their proposed action), they intend to focus tributary habitat efforts on populations where they focused effort under the 2008 biological opinions. The Action Agencies carried out actions in all three populations of this ESU under the 2008 biological opinion, and all three populations were designated as priority populations in that biological opinion.

returning flow to the stream, screening diversions, and restoring riparian areas, potential benefits of those types of actions are not included in the model results.

The modelers also had to make assumptions about what portion of the anticipated future actions (which the Action Agencies identified at the MPG level) would be implemented in the Wenatchee River population, and where and when and how. These assumptions are described in Pess and Jordan, eds. (2019) and Jorgensen and Bond (2020). For example, modelers assumed that actions would be implemented in the same watersheds where they had been in the past (i.e., the White River, Nason Creek, and the Chiwawa River within the Wenatchee River subbasin), that habitat access actions would open habitat of type and quality similar to that currently available, and that actions to improve complexity would be implemented in locations adjacent to habitat currently in moderate or good condition. Based on model results, the proposed actions would increase juvenile rearing capacity by 3 percent in the Chiwawa River, 5.2 percent in Nason Creek, and 3.5 percent in the White River. The scale of the actions, however, was not large enough to have a measurable effect on future abundance or extinction risk (Jorgensen and Bond 2020). (Changes in abundance of natural-origin spawners and extinction risk for this population as a result of these actions are captured in the life-cycle modeling results discussed in Section 2.6.3.1.12.) Importantly, this does not mean that the actions are not providing a benefit, especially when viewed in the context of long-term implementation of habitat improvement actions.[234] In addition, it provides information useful in considering implementation strategies for the UCR spring-run Chinook salmon ESU. Life-cycle models are not available at this time to estimate the benefits of prospective tributary habitat improvement actions for the Entiat and Methow spring Chinook salmon populations.

In general, implementation of the tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will likely provide near-term and long-term benefits to the targeted populations by improving their tributary habitats in the manner and timeframes outlined in Table 2.6-13, above. These improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations, although based on life-cycle modeling results and the amount of actions proposed, these improvements will likely be modest. Certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change (Beechie et al. 2013, McCullough et al. 2016, Justice et al. 2017; also see Appendix A for additional discussion). Further, Crozier et al. (2019) looked at methods of increasing climate resilience for Pacific salmon and steelhead and concluded that reducing any anthropogenic stressor could improve

[234] See Appendix A for more discussion of the complexities of measuring the effects of habitat actions. Actions may be having a benefit even though that benefit cannot be detected in modeling or monitoring results for various reasons, including countervailing effects such as ocean conditions or increased predation, variability in life-stage survivals, the fact that not a large enough portion of a watershed or the right factors have yet been treated, and, in the case of models, uncertainty in assumptions or parameters.

response to climate change by improving the overall status of an ESU (in terms of abundance, productivity, spatial structure, and diversity), thereby making the ESU more resilient and less vulnerable to stochastic extinction. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action.

2.6.3.1.9 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail in the site-specific biological opinions referenced therein (see Section 2.6.2.2.2). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.6.3.1.10 Predation Management

Avian Predators

Avian Predators in the Lower Columbia River Estuary

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions are likely to continue current levels of predation at these colonies, which, in the case of Caspian terns, is an average annual reduction of 2.4 percent from the pre-colony management period. However, ocean conditions, including compensatory effects such as the number and behavior of predators and competition for prey, will determine whether this reduction in tern predation influences adult returns. Although there appears to have been a small decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 3.7 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, cormorant predation in the estuary may be an increasingly important source of mortality for UCR spring-run Chinook salmon.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency–managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none have been proposed at this time.

Avian Predators in the Hydrosystem Reach

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia River dams. At each dam, bird numbers will continue to be monitored, birds foraging in dam tailraces will be hazed (including, in some circumstances, lethal reinforcement), and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas, and juvenile bypass outfall areas, will also continue. If proven biologically and cost effective, the Corps will deploy laser systems to haze birds foraging near bypass outfalls. Upgrades to existing systems, including bird wires at McNary Dam, will be coordinated through the FPOM and included in the annual Fish Passage Plans. We expect that these measures will continue to reduce predation on juvenile UCR spring-run Chinook salmon, although Zorich et al. (2012) were unable to quantify the amount of protection.

The Action Agencies propose to continue to address Caspian tern predation on lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015 but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. These measures are likely to continue to reduce overall predation rates on UCR spring-run Chinook salmon by Caspian terns. Reclamation will continue passive and active dissuasion efforts for Caspian terns on Goose Island. They have coordinated the timing and duration of the proposed work with USFWS to ensure it will be effective in maintaining the management objectives of fewer than 40 breeding pairs at this site, consistent with the IAPMP. This ongoing suite of colony management actions is likely to continue current levels of predation by terns in the interior Columbia River basin, which is a small improvement compared to the pre-conoy management period.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency–managed lands in the hydrosystem reach are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

John Day Reservoir—Spring Operations to Reduce Predation Rates by Caspian Terns

The Action Agencies propose to hold the elevation of John Day Reservoir at 264.5 to 266.5 feet from April 10 to June 1 or no later than June 15 each year, or as feasible based on river flows, to inundate bare sand habitat and deter Caspian terns from nesting in the Blalock Islands Complex. Because foraging effort and predation rates increase once chicks hatch, the Action Agencies will begin to increase the reservoir's elevation before Caspian terns initiate nesting (i.e., operations may begin earlier than April 10). The Action Agencies will consider bird observations along with the run timing of juvenile steelhead to determine the dates each year. At the conclusion of this operation, the draft to operating range (262.5 to 264.5 feet) will be completed within 4 days. In general, 95 percent of the juvenile steelhead migration passes John Day Dam by June 1 (DART 2020m).

The timing of this operation is based on the expectation that Caspian terns will begin colonizing exposed habitat and start courtship and nest building within days to weeks of returning the reservoir to the 262.5 to 264.5-foot range. In general, chicks hatch about 27 days after eggs are laid, at which point energetic demands and fish consumption rates increase substantially. Thus, we expect that inundating bare sand habitat until most yearling steelhead pass John Day Dam will also reduce predation rates on yearling migrants from the UCR spring-run Chinook salmon ESU.

Fish Predators

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. This fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the numbers of Chinook, including some from the UCR spring-run Chinook salmon ESU, handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy) will be no more than 100 adults (including jacks) and 200 juveniles per year, system-wide. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams and will conduct test fisheries at additional dam projects on the Snake River as described in the proposed action (BPA et al. 2020). This may help to further reduce predation on juvenile salmonids, but the likelihood of the program being implemented at additional Columbia River dams (which would produce greater benefits for UCR spring-run Chinook salmon) is not reasonably certain to occur. We estimate that no more than 10 adults (including jacks) and 20 juvenile Chinook salmon, including some from the UCR spring-run Chinook salmon ESU, will be caught in the Dam Angling Program per year.

These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear;

however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including UCR spring-run Chinook salmon.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea-lion excluder gates at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and BPA will continue to support land- and water-based harassment efforts to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually. The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management (FPOM) Coordination Team and the Sea Lion Task Force, to address changing circumstances as they relate to supporting sea lion harassment efforts and monitoring of sea lion predation at Bonneville Dam. These ongoing measures, in addition to removal efforts, are expected to maintain or reduce current levels of sea-lion predation on UCR spring-run Chinook salmon in the Bonneville tailrace. In the last 10 years, pinnipeds have consumed 1.2 to 5.9 percent of spring Chinook salmon annually at Bonneville Dam (Tidwell et al. 2020); this rate is expected to be the same, or lower, for the later migrating UCR spring-run Chinook salmon and will continue under the proposed action. If pinnipeds are observed at The Dalles Dam, the Corps may respond with hazing at adult fish ladder entrances.

2.6.3.1.11 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult UCR spring-run Chinook salmon are likely to be present in shallow shoreline areas, an unknown portion of the ESU will continue to be stunned, harmed or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this ESU that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[235]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of UCR spring-run Chinook salmon will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS:
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - 9,600 hatchery and 8,620 natural-origin juveniles will be handled.
  - 192 hatchery and 172 natural-origin juveniles will die.

- Activities associated with all other RME programs:
  - 300 hatchery and 300 natural-origin adults will be handled.
  - 10 hatchery and 10 natural-origin adults will die.
  - 2,870 hatchery and 9,992 natural-origin juveniles will be handled.
  - 21 hatchery and 133 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program will, on average, affect no more than 8.6 percent of the natural-origin adult (recent, 5-year average) run (at the mouth of the Columbia River) and 3.8 percent of all naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to less than 1 percent of estimated ESU abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs

[235] Ongoing and future discussions are expected to lead to substantial reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the effects of the RME programs on abundance are acceptable and warranted.

2.6.3.1.12 Life-Cycle Modeling

Life-cycle models comprise components estimating downstream survival through the CRS and other dams, ocean survival, adult upstream survival to the spawning grounds, and the number of juvenile fish produced and their subsequent survival in the tributaries. NMFS used life-cycle models to assess the effect of proposed hydropower system operations, the future effect of habitat restoration actions (where they could be quantified), the effect of continuing hatchery production (in accordance with the most recent HGMPs), and the effect of recent, seasonally variable increases in sea lion predation in the lower Columbia River from the mouth to Bonneville Dam. A time period of 24 years forward from the proposed action was selected as a reasonable timeframe to assess parameters generated by the model, including estimates of QET and projected geomean spawner abundance. A detailed description of the model used for Upper Columbia Spring Chinook is available in Zabel and Jordan (2020).

The QET is an estimate of the probability of a population falling below the level for 4 consecutive years at which it may be too small to successfully reproduce and be at increased risk from demographic stochasticity, genetic processes, and environmental variability. This is because the generation time of Chinook salmon is approximately 4 years, so at any given time there are four extant year classes from a basin. If the populations fall below the QET for 4 consecutive years, then all year classes of the population are considered to have dropped below the QET. Because the exact number at which this condition occurs for Chinook salmon populations is unknown and likely to be reached at population sizes significantly greater than zero, past biological opinions (e.g., NMFS 2008a) provided QET projections for 50, 30, 10, and one individual. In this opinion, NMFS presents QET projections for 50 adults as a useful means of illustrating differences resulting from factors affecting the modeled populations. More detailed outputs, including QET projections for 30 adults, are presented in Appendix C. Within the UCR spring-run Chinook salmon ESU (North Cascades MPG), only one population (Wenatchee River) has sufficient information available to support life-cycle modeling. This population is also affected by ongoing hydrosystem actions and by increased sea-lion predation, and inhabits a subbasin in which the spawning and rearing habitat is degraded.

This population has been targeted for habitat restoration actions and will continue to be substantially influenced by hatchery produced fish. Estimated effects of habitat improvements were incorporated into the model in equal increments at years 5, 10, and 15. This reflects a reasonable approximation of an implementation schedule that would allow the Action Agencies to complete the actions committed to in the proposed action.

Proposed tributary habitat actions were modeled as increases in habitat capacity, and direct effects of proposed CRS operations were modeled using the COMPASS downstream survival model.

Models were run for 1,000 iterations, and the distribution of results are reported. We use percentiles to describe the distributions of results. The median is the point where 50 percent of the estimates are greater or less than that point, the 25th percentile is the point where 75 percent of the estimates are greater than that point, the 75th percentile represents the point where 25 percent of the estimates are greater than that point, and the 95th percentile and 5th percentile represent the upper and lower 5 percent of these distributions. In interpreting these results, we consider the estimates nearest the median to be the most likely outcomes, with likelihood decreasing as estimates get further from the median. More detailed outputs, including the 5^{th} and 95^{th} percentile abundance projections, are presented in Appendix C.

Results of modelling for the Wenatchee River populations are presented in Figure 2.6-9 and Table 2.6-14.

Table 2.6-14. Life-cycle model projections of median abundance and quasi-extinction risk threshold of 50 (25th and 75th percentiles) for the Wenatchee River Population in 24 years (year 15 to 24) under the proposed action, and assuming a 17.5 percent increase in survival resulting from CSS hypothesized reduction's in latent mortality.

Upper Columbia Spring Chinook						
Wenatchee River Population	**Estimated Abundance**			**Probability of QET 50**		
	25th	**Median**	**75th**	**25th**	**Median**	**75th**
Natural origin only						
Proposed Action	330	543	898	0.00	0.00	0.00
Proposed action + 17.5%	432	716	1188	0.00	0.00	0.00
Natural and hatchery origin						
Proposed Action	839	1130	1576	N/A		
Proposed action + 17.5%	995	1369	1986			

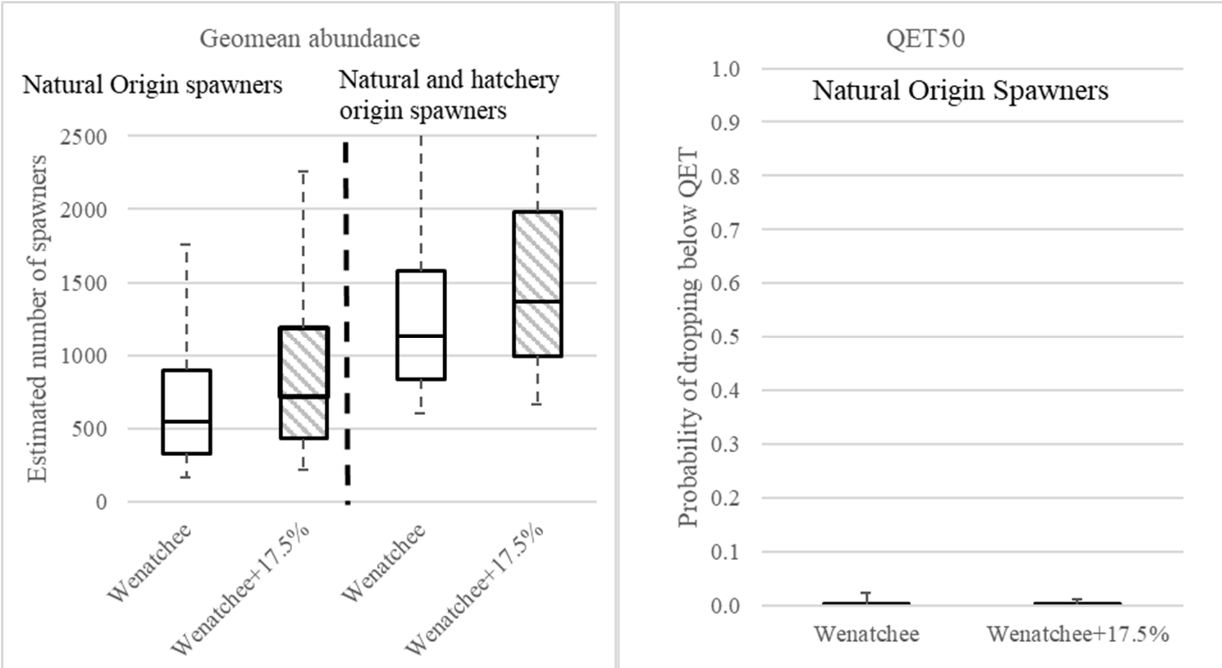

Figure 2.6-9. Life-cycle modelling projected estimates of 10-year geomean spawner abundance (years 15–24) and quasi extinction risk for a 24-year model period for the Wenatchee population of the Upper Columbia Spring Chinook ESU. Boxes bound the 25–75 percent quartiles, the central line indicates the median, and error bars indicate the 5th and 95th percentiles. Categories include projected estimates for natural-origin spawners only, and for natural-origin and hatchery spawners. "PA" indicates the proposed action, and "PA +17.5%" indicates the proposed action including a 17.5 percent improvement in adult returns due to potentially reduced latent mortality.

In general, the life-cycle model projections indicate that the Wenatchee River population is relatively stable with a low probability of falling below a QET of 50 spawners (Table 2.2-29). In addition, the modelling projections indicate that a potential increase in productivity (up to 17.5 percent) would be expected to further increase abundance and further reduce the probability of falling below the QET of 50 spawners.

The current version of the Wenatchee River population model does not include the projected effects of climate change in either the freshwater or ocean components of the population's life cycle. Since adult returns of UCR spring-run Chinook salmon generally respond in the same manner as SR spring/summer Chinook salmon, they can be reasonably assumed to react to climate change in a similar manner. Life-cycle models for SR spring/summer Chinook salmon that included projections of future climate scenarios predicted substantially reduced spawner abundance and increased risk of falling below QET, primarily as a result of projected reductions in survival in the marine environment. If UCR spring-run Chinook salmon respond similarly to climate change, then we predict that the abundance would decline substantially and the likelihood of falling below QET 50 would increase for the Wenatchee population (as well as for the Methow River and Entiat River populations that were not modeled).

Both projected abundance and QET estimates include an alternative analysis with an estimated 17.5 percent increase in adult return due to reduced latent mortality effects from increased spill and reduced powerhouse passage. The CSS hypothesis proposes that fish that pass through bypass systems (powerhouse passage) suffer some effect that results in lower chances of returning as an adult. This hypothesis is based on observations that PIT-tagged fish observed in bypass systems have lower chances of returning as adults (Budy et al. 2002, Petrosky and Schaller 2010, Buchanan et al. 2011, Haeseker et al. 2012, Schaller et al. 2013). The CSS has not actually estimated a latent mortality effect for UCR spring-run Chinook salmon, but since UCR spring-run Chinook salmon and SR spring/summer Chinook salmon both pass through the lower four dams of the CRS, 50 percent of the effect was considered a reasonable estimate (upper limit) of the possible benefit.

However, another possible explanation for reduced return probabilities of bypassed fish is that smaller fish and those in poorer condition are more likely to enter bypass systems (Zabel et al. 2005, Hostetter et al. 2015, Faulkner et al. 2019), and smaller fish and fish in poorer condition also have lower return probability (Ward and Slaney 1988, Zabel and Williams 2002, Evans et al. 2014). This suggests that apparent effects of bypass on return probability could be at least in part due to correlation between bypass probability and fish size and condition and not due to sublethal effects caused by the bypass passage itself. This indicates that the proposed increased levels of spill, while slightly improving direct survival rates, may not increase adult returns to the levels hypothesized by the CSS. Additionally, there is a non-linear relationship between the amount of spill and the number of fish passing through the spillway, with the number of additional fish passing by spillway rather than powerhouse decreasing as spill rate increases. Increased levels of spill at projects in the lower Columbia River (excepting The Dalles dam which will continue to spill at 40) are also expected to result in decreased travel times, which would likely provide a small, incremental improvement in adult return rates.

2.6.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small reduction in obstructions for juvenile inriver migrants at the four mainstem dams in the lower Columbia River. Adults migrating during periods of gas cap spill are likely to experience a small increase in obstructions due to an increased rate of involuntary fallback over the spillway. Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.6-15.

Table 2.6-15. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the UCR spring-run Chinook salmon ESU.

Physical and Biological Feature (PBFs)	Effects of the Proposed Action
Freshwater spawning sites and freshwater rearing sites	The Action Agencies will implement tributary habitat improvements to achieve the MPG-level metrics outlined in Table 2.6-12. These actions are likely to improve water quality (e.g., temperature), water quantity, substrate, floodplain connectivity, forage, and natural cover at the local scale in watersheds with spawning and rearing sites. After the first 5-year period, the proposed metrics may be adaptively managed to optimize fish benefits and the functioning of spawning and rearing sites.
Freshwater migration	Continued alteration of the seasonal flow regime (increased fall and winter and

Physical and Biological Feature (PBFs)	Effects of the Proposed Action
corridors	decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years.
	Proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not affect the functioning of water quantity in the juvenile and adult migration corridors.
	Continued alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring, when juvenile and adult UCR spring-run Chinook salmon are migrating and warmer temperatures in the late summer and fall. In general, cooler spring temperatures will not adversely affect the functioning of the mainstem as a migration corridor. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations.
	Continued reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume, which may reduce "natural cover" in the migration corridor for all populations. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations.
	Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill at the CRS run-of-river projects in the lower Columbia River. The effect on water quality in terms of increased risk of GBT is likely to be very small.
	The Corps will continue to protect water quality by using best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water.
	The flexible spring operation to 125 percent TDG will increase obstructions in the adult migration corridor by a small amount by increasing the risk of fallback over project spillways and by degrading tailrace hydraulic conditions at John Day Dam, which may contribute to passage delays for migrating adults.
	The flexible spring operation to 125 percent TDG will reduce obstructions in the juvenile migration corridor by a small amount by increasing the likelihood of spillway passage. However, the increased spill levels are likely to degrade tailrace conditions at John Day Dam and are also likely to increase the risk of bird and fish predation.
	Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions for juveniles and adults by a small amount because some will pass downstream or fall back through a turbine unit.
	Increased operating range for John Day Reservoir will reduce the risk of avian predation while increasing juvenile travel times by a small amount (small reduction in excessive predation and slight increase in obstructions).
	Continued small increases in obstructions for adult spring-run Chinook salmon during routine outages of fishways or turbine units. Very small increases in obstructions for

Physical and Biological Feature (PBFs)	Effects of the Proposed Action
	juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities (e.g., to upgrade turbines at Ice Harbor, McNary, and John Day Dams and for a major repair such as the jetty and retaining wall at Little Goose Dam). Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Long-term effect of turbine upgrades will be reduced obstructions (improved turbine survival). Repairing the jetty at Little Goose Dam will also reduce obstructions for adults at that project. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Continued implementation of the Action Agencies' bird, fish, and pinniped predator management programs will continue recent levels of predation risk in the juvenile and adult migration corridors.
Estuarine areas	Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels and juvenile and adult forage. This will increase access to prey for yearling Chinook that remain in the mainstem. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation risk in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.6.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in Status (Section

2.6.1), Environmental Baseline (Section 2.6.2), and Effects of the Action (Section 2.6.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat, and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including UCR spring-run Chinook salmon.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired) and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.6.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.6.3) to the environmental baseline (Section 2.6.2), and the cumulative effects (Section 2.6.4), taking into account the status of the species and critical habitat (Section 2.6.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.6.5.1 Species

The UCR spring-run Chinook salmon ESU comprises a single MPG that includes three extant populations originating below natural and manmade barriers in the Wenatchee, Entiat, and Methow Rivers. One population (Okanogan River) is extirpated. Two additional spring-run Chinook MPGs likely spawned above Grand Coulee and Chief Joseph Dams, but these MPGs are also extirpated as part of the existing conditions. The most recent 5-year status review indicated that there have been improvements in total and natural-origin abundance, but the populations were still considered at high risk. All three populations need to be at least viable to achieve ESA recovery goals. Recent adult returns (2014 to 2018) for each of the three populations have been substantially (22 to 41 percent) below 2009-2013 returns. This downturn is associated with a marine heatwave and its lingering effects, which likely contributed to substantially lower ocean survival rates of juvenile spring Chinook salmon. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants. However, jack returns suggest that adult numbers could remain at low levels in 2021.

UCR spring-run Chinook salmon pass the four lower Columbia River mainstem dams, as well as three (Wenatchee River), four (Entiat River), or five (Methow River) FERC-licensed mainstem dams in the Columbia River located between McNary and Chief Joseph Dams. Conditions for UCR spring-run Chinook salmon populations have generally improved in the mainstem Columbia River because of the installation and operation of surface passage routes, 24-hour spill, improved spill patterns, and improvements to the juvenile bypass systems at the mainstem dams. McNary to Bonneville survival rates for ESA-listed UCR spring-run Chinook salmon vary substantially but have averaged about 81 percent in the past 10 years (2010 through 2019) (Zabel 2019, Widener et al. 2020). Performance standards testing at the mid-Columbia PUD FERC-licensed projects indicates that recent average juvenile survival rates to Priest Rapids tailrace are about 74 percent for juveniles from the Okanogan and Methow Rivers (five reservoirs and dams), 76 percent for juveniles from the Entiat River (four reservoirs and dams), and 81 percent for juveniles from the Wenatchee River (three reservoirs and dams).

The juvenile survival rates from the FERC-licensed mainstem dams to McNary Dam and from McNary Dam to Bonneville Dam include all sources of mortality, even those that are not caused by the past or proposed operation and maintenance of the CRS. For instance, regardless of the operational or configurational choices made for the hydrosystem, some predation and other natural mortality of juvenile SR spring/summer Chinook salmon would occur during their migration. In addition, juvenile survival is influenced by past and present alterations of shoreline habitat, among other stressors, unrelated to the effects of operating the hydrosystem; many of those effects will continue into the future. We are unable to differentiate the proportion of the losses that result from the operation and maintenance of the mainstem dams rather than to the existence of the dams, but we know that the mortality attributable to operations and maintenance is less than the losses captured in the overall survival estimates. As discussed further below, some also hypothesize that passage through juvenile bypass systems and turbines causes latent mortality, which would not be captured in the direct survival estimates.

Adult survival rates (adjusted to account for reported harvest and typical straying rates), include "natural" mortality as well as any mortality associated with injuries incurred from predators. Adult survival rates for UCR spring-run Chinook salmon are relatively high, averaging about 94 percent from Bonneville and McNary Dam, 97 percent from McNary to Priest Rapids, and 96 percent from Priest Rapids to Wells Dam. Increased spring spill levels at some of the lower Columbia River dams are expected to slightly increase adult fallback rates. Not all individuals that fall back will successfully reascend the fishways, and those that do will experience some delay. However, the potential for loss will be reduced by the fact that more of these adults will have fallen back through spillbays, which have higher survival rates than juvenile bypass systems or turbine units.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Overall, scheduled maintenance activities are expected to continue to negatively affect very few UCR spring-run Chinook salmon that are migrating during scheduled maintenance periods. Non-routine and unscheduled maintenance can affect juvenile and adult passage and survival, especially if these events occur during the freshet, but because they are sporadic in nature and coordinated through the inseason adaptive management process, the alternative measures as coordinated in FPOM (e.g., alternative spill, or turbine unit priorities) will likely minimize these impacts.

The proposed spring spill levels would implement a program of voluntary fish passage spill with the highest spill volumes ever implemented. This will increase juvenile exposure to higher TDG levels; however, it is unlikely that spilling up to 125 percent TDG for 16 hours per day at mainstem dams[236] will result in any substantial, negative impacts to juvenile survival (or adult passage) because there are sufficient data and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). In 2020, implementation of spring spill up to 125 percent TDG did not cause GBT symptoms at levels of concern. In addition, there is sufficient monitoring and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). The proposed 125 percent flexible spill operation could slightly improve direct juvenile survival rates through the four lower Columbia river mainstem projects (with the possible exception of

[236] Except at John Day Dam, The Dalles, and Bonneville Dam, where proposed spill operations are limited to 120 percent TDG, 40 percent spill, and 150 kcfs, respectively.

Bonneville Dam, where survival rates could decrease slightly, and at The Dalles Dam, which will maintain spill levels of 40 percent). NMFS' COMPASS model predicts that inriver survival rates will increase slightly as a result of increased spring spill levels associated with the flexible spill operation compared to the No Action Alternative (USACE et al. 2020). The CSS model predicts more substantial increases in juvenile survival, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillbays) will increase adult returns of the Snake River populations by about 35 percent. If this is the case, to the extent that UCR spring-run Chinook salmon experience latent mortality associated with dams, higher spill levels would be expected to increase adult returns accordingly. For the purposes of life-cycle modeling, we evaluated an increased adult return of 17.5 percent, half that hypothesized by the CSS for SR spring/summer Chinook because they pass through half as many Federal projects. If these predictions are realized, they would represent a near-term improvement in productivity and abundance for UCR spring-run Chinook salmon (as demonstrated by NMFS' life cycle modeling of the proposed action plus a 17.5 percent productivity improvement for the Wenatchee River population) and, over time, would somewhat reduce the severity of expected declines in abundance and productivity caused by a warming climate and deteriorating ocean conditions.

Tributary habitat conditions for UCR spring-run Chinook salmon are generally good in high elevation reaches but degraded in lower elevation reaches, particularly near valley bottoms, as a result of past and present land uses. Generally, the ability of tributary habitat to support the viability of UCR spring-run Chinook salmon is limited by one or more of the following factors: 1) reduced stream complexity and channel structure, 2) reduced floodplain condition and connectivity, 3) degraded riparian conditions, 4) diminished stream flow, 5) impaired fish passage, 6) excess fine sediment, and 7) elevated summer water temperatures.

Many habitat improvement actions have been implemented in the subbasins occupied by UCR spring-run Chinook salmon (i.e., the Wenatchee, Entiat, and Methow subbasins). These actions have been targeted toward addressing limiting factors and have included protecting and improving stream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. NMFS has determined that these actions have improved, and will continue to improve, habitat in the targeted populations as these projects mature, and that fish population abundance, productivity, spatial structure, and diversity will respond positively. The benefits of some of these actions will continue to accrue over several decades. At the same time, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

While some degraded tributary habitats in the UCR spring-run Chinook salmon ESU are likely on an improving trend, in general tributary habitat conditions are still degraded. These degraded habitat conditions continue to negatively affect spring-run Chinook salmon abundance, productivity, spatial structure, and diversity. The potential exists to further improve tributary habitat capacity and productivity in this ESU. Additional tributary habitat improvements are needed to achieve recovery goals.

Implementation of the tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will provide additional near-term and long-term benefits to the targeted populations by improving tributary habitat in the manner and timeframes outlined in Table 2.6-12, above. In addition, certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change (Beechie et al. 2013, McCullough et al. 2016, Justice et al. 2017). Crozier et al. (2019) looked at methods of increasing climate resilience in their 2019 climate vulnerability assessment for Pacific salmon and steelhead. They found that reducing anthropogenic stressors could greatly improve responses to climate change by improving the overall status of an ESU in terms of abundance, productivity, spatial structure, and diversity. A robust ESU has greater resilience by virtue of strong population dynamics that make stochastic extinction less likely. Actions implemented to ameliorate limiting factors for any population would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced.

These improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations, although based on life-cycle modeling results and the number of actions proposed for this ESU, these improvements will likely be modest. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for others, benefits will take several years to fully accrue (this could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action. Further, to yield substantial improvements, it is necessary to implement a large scale and scope of habitat improvement actions (e.g., implementation over a 25-year time period or longer), and to implement actions throughout a large portion of each watershed. Thus, it is important to consider the results of the habitat actions to be implemented under this proposed action in the context of the effects of long-term implementation of habitat actions.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving UCR spring-run Chinook salmon abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this ESU. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan, the Double-crested Cormorant Management Plan, and the IAPMP, as well as hazing at the mainstem dams. For UCR spring-run Chinook salmon, we expect that management of tern colonies throughout the basin is reducing mortality by a small amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that prey on yearling Chinook salmon are also present in the hydrosystem reach. Increasing the John Day reservoir elevation in the spring should control impacts from the Blalock Islands tern colony. The NPMP and dam angling program are expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested Cormorant Management Plan, these programs will maintain current (reduced) levels of predation, creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

The largest harvest-related effects on UCR spring-run Chinook salmon result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery and estimated that harvest rates would continue to average around 11 percent (including an estimated 10 percent mortality of wild-released fish). In addition, mark-selective fisheries operate in the Wenatchee River basin and above Wells Dam. Fisheries for non-ESA-listed fish also occur that may have incidental impacts on UCR spring-run Chinook salmon.

Pinniped predation on UCR spring-run Chinook in the lower Columbia River and estuary has increased substantially with recent increases in the abundance of sea lions, especially in the spring. However, estimated losses in the Bonneville tailrace have declined recently, ranging from about 3 to 5 percent since 2016. Sea lion predation downstream of Bonneville Dam, including the estuary, continues to substantially and negatively affect the productivity and abundance of UCR spring-run Chinook salmon.

The past effects of artificial production programs have largely been to increase abundance and help preserve genetic resources—especially true for safety net or conservation hatchery programs during times of low abundance. However, these programs have also posed risks to natural productivity and genetic diversity. The management of UCR spring-run Chinook salmon hatchery programs has generally improved substantially compared to historical operations.

Recently authorized HGMPs will minimize impacts to naturally produced populations within this ESU, but these benefits may not be fully realized for several generations of fish. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of UCR spring-run Chinook salmon.

As described in Section 2.6.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect UCR spring-run Chinook salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of UCR spring-run Chinook salmon as high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change. However, the severity of those changes would be somewhat reduced as a result of the proposed action.

Adults migrants could potentially respond temporally to changing environmental conditions by migrating earlier in the spring, but would still be exposed to higher summer temperatures as they hold in tributary streams before spawning. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or winter flood events). Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in streams and in the estuary. Juveniles using a stream-type, yearling life history strategy would be exposed to higher summer temperatures in tributaries, though juvenile migrants could potentially respond temporally by migrating earlier in the spring. Though the quality of information is mixed, sensitivity in the marine stage is certainly high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur.

NMFS’ life-cycle modeling (for SR spring/summer Chinook salmon), which considered three potential levels of changing climate severity over the next 24 years, clearly indicates that climate change effects, especially those that may manifest in the ocean, pose a substantial threat as they can have severe, negative consequences to the overall productivity (and abundance) of all SR spring/summer Chinook salmon populations (see Section 2.2.3.1.12 Life-Cycle Modeling), and likely to other “stream type” Chinook salmon populations, like UCR spring-run Chinook salmon, as well. These climate change consequences are not caused by the proposed action, and elements of the proposed action (flexible spring spill operations, tributary and estuary habitat restoration and research, monitoring, and evaluation programs) should help to improve the resiliency of UCR spring-run Chinook salmon populations to expected climate change effects. In simple terms, even if the adult abundance declines as predicted under climate change, which will make recovery of this ESU more challenging, it will have declined less as a result of the proposed action because in many ways the proposed action is expected to improve the functioning of VSP parameters and thus positively contribute to the survival and recovery of the species.

The proposed action—the future operation and maintenance of the CRS (including upper Columbia River operations and Dworshak Dam winter operations to reduce TDG in the lower Clearwater River)—will have little overall effect on the seasonal hydrograph or seasonal temperatures compared to recent conditions. The seasonal hydrograph will continue to be altered, generally increasing flows in the fall and winter and reducing flows in the spring. Seasonal water temperatures will also continue to be altered, with delayed warming in the spring, delayed cooling in the fall, and reduced daily temperature variability. These effects to river conditions likely adversely affect the survival of UCR spring-run Chinook salmon, but to an extent not readily quantified based on the best available information.

Other operations (e.g., operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, increasing the John Day reservoir operating range during the spring to reduce avian predation, etc.) are, collectively, expected to have small negative effects, especially on juvenile migrants, but these effects should not measurably alter survival estimates between McNary Dam and Bonneville Dam.

The proposed action includes many measures to reduce the adverse effects of the passage impediments caused by the existence of the CRS, including juvenile fish passage spill, operation of juvenile bypass systems, attraction flows for adults, and the operation of adult fish ladders. In addition to these measures, the proposed flexible spring spill operation is expected to improve juvenile survival through the mainstem migration corridor for all populations, and if the flexible spring spill operation increases adult returns by up to 17.5 percent (half that hypothesized by the CSS for SR spring/summer Chinook salmon), UCR spring-run Chinook salmon would experience a substantial near-term improvement in productivity and adult abundance over current conditions.

Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this ESU (e.g., dam passage survival, population productivity, degraded tributary and estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.).

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity and is likely to affect marine survival (to an unknown extent) through latent mortality. Since 2008, actions have been taken to reduce adverse impacts associated with the operation of the CRS and to address factors limiting survival and recovery (e.g., tributary and estuary habitat, predation, etc.). Evidence shows that these actions have resulted in improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The recent downturn in adult abundance (2014 to 2019) is primarily the result of recent poor ocean conditions and not of altered tributary and mainstem habitat conditions. The proposed action carries forward structural and operational improvements implemented since 2008 and improves upon them. Additional juvenile survival improvements are expected from the flexible spring spill operation and potential improvements resulting from reduced latent mortality are possible, and ecosystem functions should continue to increase in tributary and estuary habitats where improvement actions occur.

Climate change is a substantial threat to UCR spring/summer Chinook salmon, especially during the marine rearing phase of their life cycle. The proposed action is expected to reduce both the scope and severity of those impacts and not exacerbate them. The proposed action therefore is expected to increase the resiliency of the populations to climate change and provide time for additional recovery actions to be implemented.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of UCR spring-run Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of UCR spring-run Chinook salmon.

2.6.5.2 Critical Habitat

NMFS designated critical habitat for UCR steelhead to include all estuarine areas and river reaches of the mainstem Columbia River and its tributaries upstream of Rock Island Dam and downstream of Chief Joseph Dam, excluding the Okanogan River subbasin. Across subbasins with PBFs for UCR spring-run Chinook salmon in the Interior Columbia Recovery Domain, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.); reduced water quality; and diminished habitat quantity, quality, and complexity. Past and current land use and water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity. As a result, the important watershed processes and functions that once created healthy ecosystems for salmon production have weakened.

Measures taken through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies, in the decades since critical habitat was designated have improved the functioning of spawning and rearing area PBFs. These include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. However, more improvements will be needed before many areas function at a level that supports the recovery of UCR spring-run Chinook salmon. Under the proposed action, the Action

Agencies will implement a suite of habitat actions to further improve the functioning of water quality (e.g., temperature), water quantity, substrate, floodplain connectivity, forage, and natural cover in spawning and rearing areas. These include enhancing flow; access; stream complexity, including floodplain connectivity; and riparian function; and screening diversions in one or more populations within the ESU. Climate change is likely to decrease streamflow (water quantity) and increase temperature (water quality) in some spawning and rearing areas, depending on their specific characteristics and locations. These risks underscore the importance of the Action Agencies' habitat restoration program, especially actions that restore riparian vegetation, streamflow and floodplain function, to improve habitat resiliency.

The environmental baseline also includes a broad range of past and present actions and activities, including effects of the hydrosystem, that have affected the conservation value of critical habitat in juvenile and adult migration corridors for UCR spring-run Chinook salmon. Some of these past effects will continue under the proposed action: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and passage delays (increase in obstructions). These factors have increased the likelihood of excessive predation on juvenile and adult UCR spring-run Chinook salmon and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The proposed action carries forward structural and operational improvements since 2008 that address these effects on PBFs and in some cases, improves upon them. The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors.

The Action Agencies also have reduced effects of their operations on juvenile salmonid travel time and survival by increasing levels of spring spill. We expect the additional flexible spring spill to 125 percent TDG to reduce water quality in the juvenile and adult migration corridors by a small amount while having a small positive effect on obstructions at CRS projects in the lower Columbia River through increased spillway passage. On the other hand, higher spill levels will increase obstructions for adults by a small amount by increasing the risk of fallback and, in low runoff years, could degrade tailrace conditions at John Day Dam, increasing the risk of bird and fish predation for juvenile migrants. However, there is sufficient flexibility through the in-season management process to identify and remedy any negative effects through modified spill patterns.

Operating turbines above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction for adults (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions by a small amount because some adults or juveniles will move downstream through turbines.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors.

In summary, the proposed action is not likely to further limit water quantity or water quality or to increase obstructions in the juvenile or adult migration corridors by a meaningful amount. In addition, if the CSS hypothesis regarding latent mortality is correct, the flexible spill program could improve the functioning of the juvenile migration corridor to a much greater extent than indicated by the likely effects on obstructions described above.

Increasing the elevation of John Day Reservoir to cover nesting areas on the Blalock Islands will limit the risk of predation by Caspian terns by delaying nesting until about 95 percent of steelhead outmigrants have passed McNary Dam, which will also protect most juvenile UCR spring-run Chinook salmon. The Action Agencies also will continue to implement measures to reduce pinniped predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the hydrosystem and the estuary, and the predation management programs for Caspian terns on the interior plateau and for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will maintain the levels of predation in the juvenile and adult migration corridors that were observed in recent years, although cormorant predation rates may further increase if more birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the estuary, many of these funded through the CRS program. The Action Agencies propose to continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling Chinook salmon migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of UCR spring-run Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of UCR spring-run Chinook salmon designated critical habitat.

2.6.6 Conclusion

After reviewing and analyzing the current status of UCR spring-run Chinook salmon and its designated critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of UCR spring-run Chinook salmon or destroy or adversely modify its designated critical habitat.

2.7 Upper Columbia River (UCR) Steelhead

This section applies the analytical framework described in Section 2.1 to the UCR steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the UCR steelhead DPS or destroy or adversely modify its critical habitat.

2.7.1 Rangewide Status of the Species and Critical Habitat

The status of the UCR steelhead DPS is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.7.1.1 Status of the Species

2.7.1.1.1 Background

On October 17, 1997, NMFS listed the UCR steelhead DPS as an endangered species (62 FR 43937), then designated it as a threatened species on January 5, 2006 (71 FR 834). The DPS was reclassified as endangered on January 13, 2007 (74 FR 42605). In 2009, the status was reclassified as threatened (74 FR 42605), and that status was reaffirmed on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that the DPS should retain its threatened status (81 FR 33468). Critical habitat for the UCR steelhead DPS was designated on September 2, 2005 (70 FR 52630). The summary that follows describes the rangewide status of UCR steelhead. More information can be found in the recovery plan (UCSRB 2007) and most recent status review for this species (NMFS 2016d).[237]

The UCR steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and artificial impassable barriers in streams within the Columbia River basin, upstream from the Yakima River, Washington, to the U.S./Canada border. The DPS comprises four independent populations, which are grouped into one MPG. It also includes steelhead from five artificial propagation programs (Table 2.7-1) (71 FR 834).[238] Historically, there were likely three MPGs (Figure 2.7-1). Two additional steelhead MPGs likely spawned

[237] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

[238] For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including UCR steelhead (81 FR 72759). The proposed changes for hatchery programs in this DPS were to change the name of the Omak Creek Hatchery Program to the Okanogan River Program. We expect to publish the final revisions in 2020.

above Grand Coulee and Chief Joseph Dams, but these MPGs are extirpated, and reintroduction is not required for recovery as defined in the ESA recovery plan (UCSRB 2007). NMFS has defined the UCR steelhead DPS to include only the anadromous members of this species (70 FR 67130).

Table 2.7-1. UCR steelhead major population groups and component populations, and hatchery programs (UCSRB 2007, 71 FR 834).

Major Population Group	***Populations***
North Cascades MPG	Wenatchee River Entiat River Methow River Okanogan River
Hatchery Programs	
Hatchery programs included in DPS	Wenatchee River Wells Complex Hatchery Program (Methow River) Winthrop National Fish Hatchery Omak Creek Ringold Hatchery

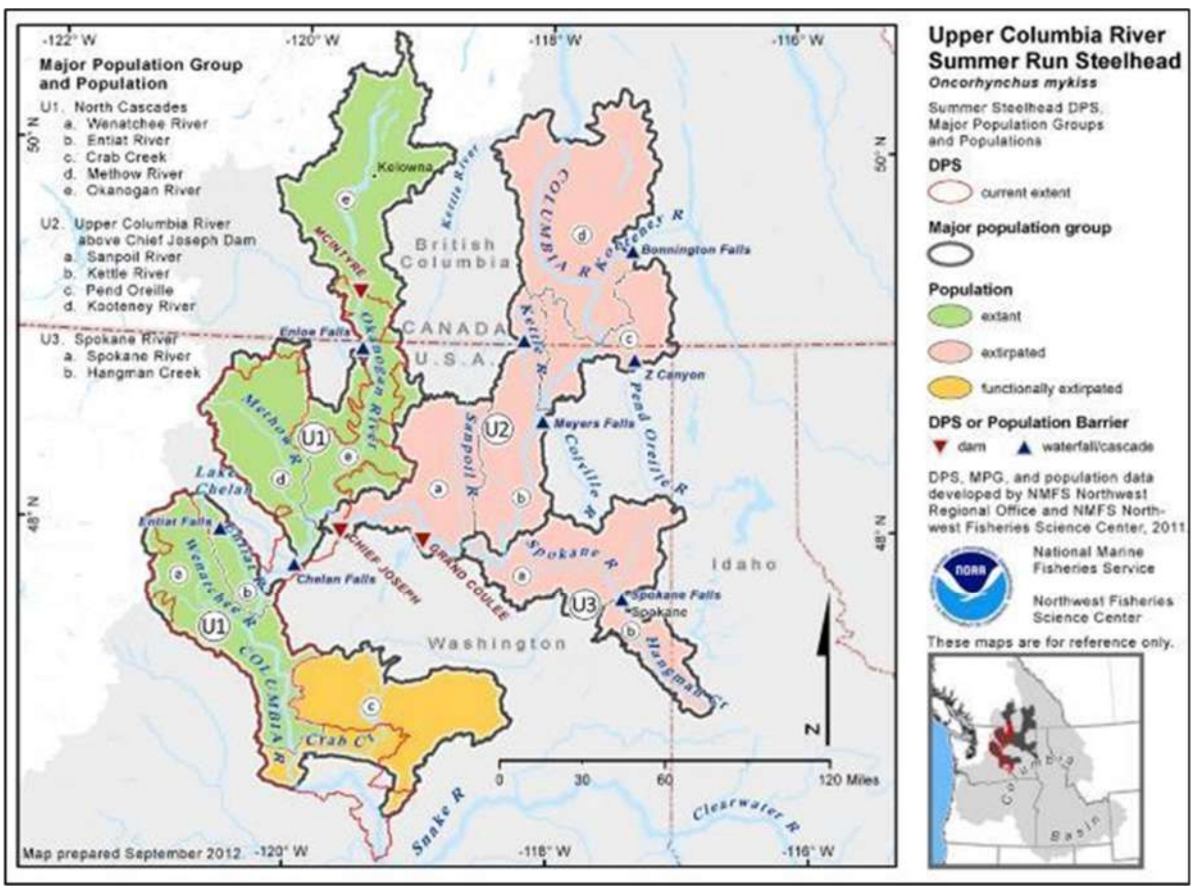

Figure 2.7-1. Map illustrating UCR steelhead DPS's populations and major population groups (NWFSC 2015).

2.7.1.1.2 Life History and Factors for Decline

The life-history pattern of steelhead in the UCR DPS is complex. UCR steelhead exhibit a stream-type life, with individuals exhibiting a yearling life-history strategy (NMFS 2016d). Adults return to the Columbia River in the late summer and early fall. Unlike spring-run Chinook salmon, most steelhead do not move upstream quickly to tributary spawning streams. A portion of the returning run overwinters in the mainstem Columbia River reservoirs, passing into tributaries to spawn in April and May of the following year. Spawning occurs in the late spring of the year following entry into the Columbia River. Juvenile steelhead generally spend 1 to 3 years rearing in freshwater before migrating to the ocean but have been documented spending as many as 7 years in freshwater before migrating. Most adult steelhead return to the upper Columbia River basin after 1 or 2 years at sea. UCR steelhead have a relatively high fecundity, averaging between 5,300 and 6,000 eggs (UCSRB 2007). Steelhead are iteroparous, or capable of spawning more than once before death.

Factors contributing to the decline of UCR steelhead included the intensive commercial fisheries in the lower Columbia River that began in the latter half of the 1800s, continued into the 1900s, and nearly eliminated many salmon and steelhead stocks. With time, the construction of dams and diversions, some without passage, blocked or impeded salmon and steelhead migrations. Early hatcheries, operated to mitigate the impacts of dams on fish passage and spawning and rearing habitat, employed practices such as transferring fish among basins without regard to their origin. While these practices increased the abundance of stocks, they also decreased the diversity and productivity of populations they intended to supplement. Concurrent with these activities, human population growth within the basin was increasing and land uses were adversely affecting UCR steelhead spawning and rearing habitat. In addition, non-native species were introduced by both public and private interests that directly or indirectly affected salmon and steelhead (UCSRB 2007).

All four extant populations spawn in tributaries to the Columbia River upstream of the confluence of the Snake River with the Columbia River. They pass the four lower Columbia River dams (Bonneville, The Dalles, John Day, and McNary), operations of which are part of the proposed action. All four populations also spawn upstream of the PUD-operated Priest Rapids, Wanapum, and Rock Island Dams on the upper Columbia River. The Entiat River population must pass one additional PUD dam (Rocky Reach) and the Methow and Okanogan River populations must pass two additional PUD dams (Rocky Reach and Wells Dams). The operation of these PUD dams is not part of the proposed action.

2.7.1.1.3 Recovery Plan

The ESA recovery plan for UCR steelhead (UCSRB 2007) includes delisting criteria for the DPS, along with identification of factors currently limiting its recovery, and management actions necessary to achieve the goals.[239] The biological delisting criteria are based on recommendations

[239] This plan was developed by the Upper Columbia Salmon Recovery Board and then reviewed and adopted by NMFS (72 FR 57303).

by the ICTRT.[240] They are hierarchical in nature, with DPS-level criteria based on the status of natural-origin UCR steelhead assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the DPS will require improvement in the abundance, productivity, spatial structure, and diversity of all four extant populations to the point that all four are considered viable.

2.7.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within the DPS based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the ICTRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low risk. Generally, each MPG must achieve low risk for the DPS as a whole to be considered no longer threatened or endangered. For the single UCR steelhead MPG to achieve low risk, all four of its extant population must achieve viable status (i.e., low extinction risk) (UCSRB 2007).

The most recent status review (NMFS 2016d) found that the most recent estimates (5-year geometric mean) of total and natural-origin spawner abundance had increased relative to the prior review for all four populations, but natural-origin abundance remained well below the corresponding ICTRT thresholds for viability (i.e., low extinction risk), with the exception of the Wenatchee River population. Evaluation of productivity indicated that recent annual brood year return-per-spawner estimates were well below replacement for all four populations, with the exception of a few years for the Wenatchee River population. Despite the fact that each population was consistently exhibiting natural production rates well below replacement, natural production had not declined consistently, but had fluctuated at levels well below recovery objectives, perhaps because the large numbers of hatchery fish on the spawning grounds each year were subsidizing spawning at levels well above the current natural carrying capacity of the system. Three of the four UCR steelhead populations continued to be rated at high risk for overall abundance and productivity. For one population—the Wenatchee—the combined abundance and productivity was rated at low risk (NWFSC 2015, NMFS 2016d).

The most recent status review (NMFS 2016d) determined that all UCR steelhead populations were at low risk for spatial structure, except the Okanogan (which was rated at high risk for spatial structure). All four populations were rated at high risk for diversity. Diversity risk was driven largely by high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations (NWFSC 2015, NMFS 2016d).

[240] The recovery plan also includes "threats criteria' for each of the relevant listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

The Entiat, Methow, and Okanogan River populations remained at high overall extinction risk, while the Wenatchee River population status was considered "maintained" as of the most recent status review (NMFS 2016d). Overall, the DPS status remained unchanged from previous status reviews and was considered at high risk. In general, risk was driven by low abundance and productivity and concerns about diversity, largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations, especially in the Methow and Okanogan Rivers (Table 2.7-2, NMFS 2016d). Recent changes in hatchery practices in the Wenatchee River provided the potential for reduced hatchery contributions or increased spatial separation of hatchery- and natural-origin spawners, which could strengthen the influence of natural selection over time.

Table 2-7.2 lists the populations in this ESU and summarizes their abundance/productivity, spatial structure, diversity, and overall population risk status as of the most recent status review (NWFSC 2015, NMFS 2016d); it also summarizes their target risk status for delisting (UCSRB 2007).

Table 2.7-2. UCR steelhead population-level risk for abundance/productivity (A/P), diversity, integrated spatial structure/diversity (SS/D), overall extinction risk as of the most recent status review (NWFSC 2015, NMFS 2016d), and recovery plan target status (UCSRB 2007). Risk ratings range from very low (VL) to low (L), moderate (M), high (H), very high (VH), and extirpated (E). Maintained (MT) population status indicates that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the DPS.

Population	ICTRT Minimum Abundance Threshold[1]	A/P Risk Rating	Diversity Risk Rating	Integrated SS/D Risk Rating	Overall extinction risk	Recovery Plan Target Extinction Risk Rating
Wenatchee River	1,000	L	H	H	MT	L
Entiat River	500	H	H	H	H	L
Methow River	1,000	H	H	H	H	L
Okanogan River	750	H	H	H	H	L

[1] Minimum abundance thresholds represent the number of spawners needed for a population of a given size category to achieve low risk (viability) at a given productivity (ICTRT 2007).

2.7.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the UCR steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. Limiting factors identified in the recovery plan (UCSRB 2017) for this DPS include (in no particular order):

- Habitat degradation: Human activities have altered and/or curtailed habitat-forming processes and limited the habitat suitable for steelhead in the upper Columbia River tributaries. Storage dams, diversions, roads and railways, agriculture, residential development, and forest management continue to cause changes in water flow, water temperature, sedimentation, floodplain dynamics, riparian function, and other aspects of the ecosystem, all of which are deleterious to steelhead and their habitat.
- Hydropower systems: Conditions for UCR steelhead have been fundamentally altered by the construction and operation of mainstem dams for power generation, navigation, and flood control. UCR steelhead are adversely affected by hydrosystem-related flow and water-quality effects, obstructed and/or delayed passage, and ecological changes caused by impoundments. Effects occur at the four Federal dams on the lower Columbia River and at FERC-licensed dams on the upper Columbia River.[241]
- Harvest: Historical harvest rates have been reduced from their peak as a result of international treaties, fisheries conservation acts, the advent of weak-stock management, regional conservation goals, and the ESA listing of many salmon ESUs and steelhead DPSs. While fisheries do not target weak stocks of listed salmon or steelhead, listed fish are incidentally caught in fisheries directed at hatchery and unlisted natural-origin stocks.
- Hatcheries: In the upper Columbia region, hatcheries producing steelhead are operated to mitigate the impacts of habitat loss resulting from the construction of Grand Coulee Dam and passage and habitat impacts of the mid-Columbia PUD dams. These hatcheries provide valuable mitigation and/or conservation benefits but can cause adverse impacts if not properly managed. These risks include genetic effects that reduce fitness and survival, ecological effects such as competition and predation, facility effects on passage and water quality, mixed stock fishery effects, and masking of the true status of natural-origin populations.
- Additional factors, including changes in estuarine habitat, climate change, inadequacy of regulatory mechanisms, fluctuating ocean cycles, and predation.

In its most recent status review, NMFS (2016d) noted that:

- Despite efforts to improve tributary habitat conditions, considerable improvement is still needed to restore habitat to levels that will support viable populations.
- Direct survival of juvenile salmonids outmigrating from upper Columbia River populations has increased as a result of juvenile passage improvements at Federal and PUD dams.

[241] All four populations spawn upstream of the PUD-operated Priest Rapids, Wanapum, and Rock Island Dams on the upper Columbia River. The Entiat River population must pass one additional PUD dam (Rocky Reach) and the Methow and Okanogan River populations must pass two additional PUD dams (Rocky Reach and Wells Dams).

- Harvest rates on UCR steelhead have been reduced from historical levels. Total exploitation rates have been stable at around the 5 to 7 percent range. Most impacts occur in tribal gillnet and dip net fisheries.
- The proportions of hatchery-origin returns in natural spawning areas remained extremely high across the DPS, especially in the Methow and Okanogan river populations, leading to high risk ratings for diversity (NWFSC 2015).
- Avian and pinniped predation on UCR steelhead had increased since the previous status review in 2011, and non-indigenous fish species remain a threat.
- Some regulatory mechanisms had improved since the previous status review, but, particularly for land-use regulatory mechanisms, there was lack of documentation or analysis of their effectiveness.
- Climate change was a concern, particularly the future effects of continued warming in marine and freshwater systems.

2.7.1.1.6 Information on Status of the Species since the 2016 Status Review

The best scientific and commercial data available with respect to the adult abundance of natural-origin UCR steelhead indicates a substantial downward trend in the number of natural-origin spawners at the DPS level from 2014 to 2019 (Figure 2.7-2). This recent downward trend in adult abundance is thought to be driven primarily by marine environmental conditions and a decline in ocean productivity (see discussion below), as hydropower operations, the overall availability and quality of tributary and estuary habitat, and hatchery practices, were relatively constant or improving over this period of time (the past 10 years).[242] Increased abundance of sea lions in the lower Columbia River could also be a contributing factor.

[242] Many factors (e.g., higher summer temperatures, lower late summer flows, low spring flows, etc.) affect the ability of tributary habitat to produce juvenile migrants (capacity) each year. Recent drought and temperature patterns may have had a negative effect on tributary habitat productivity, and as a result, lower than average juvenile production may have contributed in some years to downturns in adult abundance.

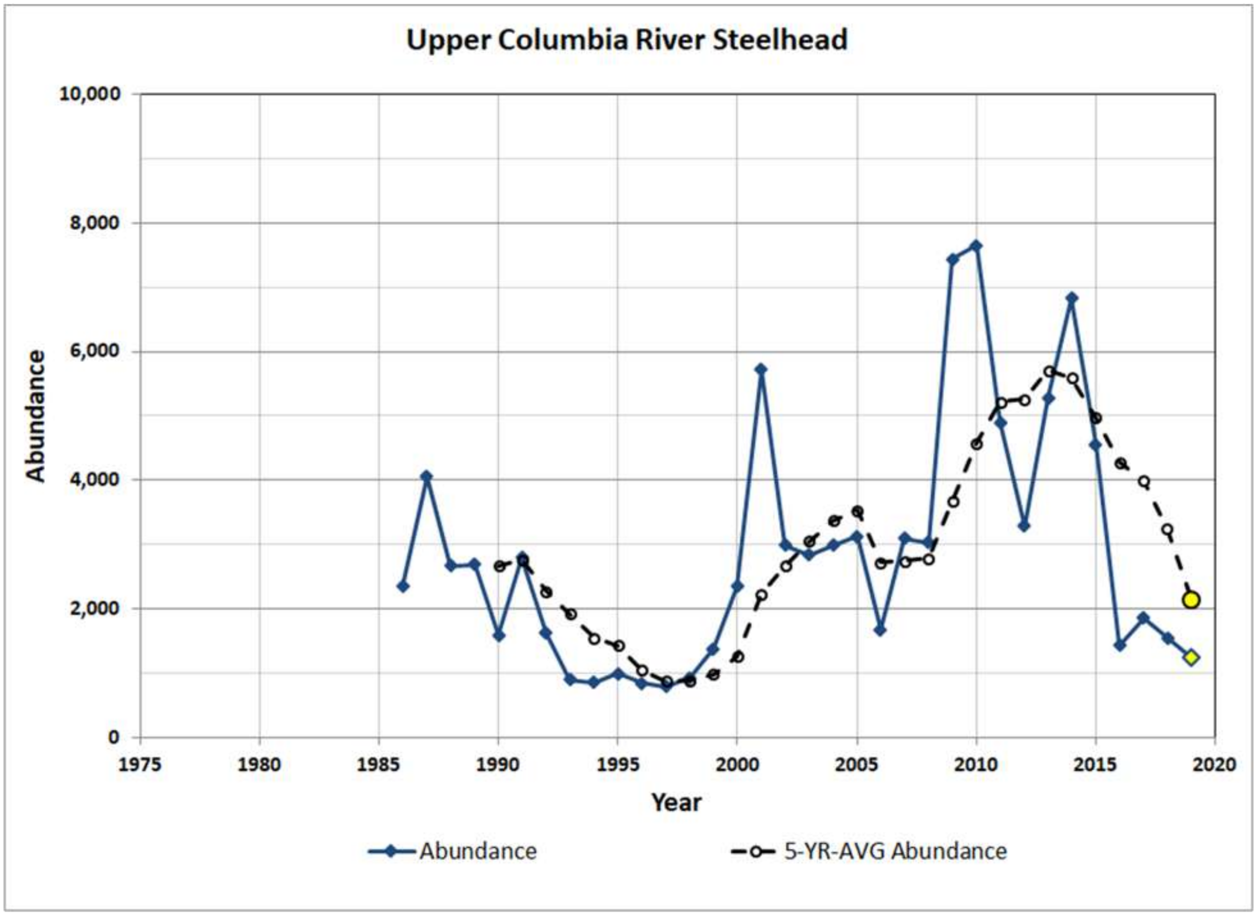

Figure 2.7-2. Annual abundance and 5-year average abundance estimates for the UCR steelhead DPS (natural-origin fish only) at Priest Rapids Dam for 1977–1978 to 2018–2019. Data for year X include passage counts occurring between July 1 of year X and June 30 of year X+1. Data for year 2019–2020 are a projection based on passage counts through December 31, 2019; average percent passage that occurs in year X; and average percent natural-origin fish. Data source: Personal communication with Andrew Murdoch of WDFW (Murdoch 2017), Ben Truscott of WDFW (Truscott 2019) and the DART (2020h) website's Adult Passage Query: http://www.cbr.washington.edu/dart/query/adult_graph_text.

Population level estimates of natural-origin and total (natural- and hatchery-origin) spawners through 2018 are shown in Table 2.7-3. These data also show recent and substantial downward trends in abundance for most of the populations (i.e., the "% Change" was negative, but of smaller magnitude for the Methow population) when compared to the 2009 to 2013 period (Table 2.7-3).[243] All populations remain considerably below the minimum abundance thresholds established by the ICTRT (shown in Table 2.7-2).

[243] The upcoming status review, expected in 2021, will include population-level adult returns through 2019, and will add a new rolling 5-year geomean, for 2015 to 2019. Because the 2014 adult returns represented a peak at the DPS level, the negative percent change between the 2015–2019 and 2014–2018 geomeans will likely be greater than that shown in Table 2.7-3 between the 2014–2018 and 2009–2013 geomeans, at least for some populations.

Table 2.7-3. 5-year geometric mean of natural-origin spawner counts (total spawner count times the estimated fraction natural-origin, if available) for UCR steelhead. Number in parenthesis is the 5-year geometric mean of total spawner counts. "% change" is a comparison between the two most recent 5-year periods (2014-2018 to 2009-2013). At the time of drafting this opinion, 2019 data were not available for any of the populations in this DPS. Source: (Williams 2020a).

MPG	Population	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change
North Cascades	Entiat River	85 (155)	37 (155)	90 (385)	100 (496)	185 (756)	105 (306)	-43 (-60)
	Methow River	270 (1382)	90 (781)	314 (3342)	516 (3747)	770 (4208)	708 (2232)	-8 (-47)
	Okanogan River	81 (789)	22 (456)	89 (1744)	179 (1359)	335 (2324)	263 (1080)	-21 (-54)
	Wenatchee River	667 (2163)	271 (946)	632 (1511)	669 (2064)	1356 (2773)	639 (1208)	-53 (-56)

NMFS will evaluate the implications for viability risk of these more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure as well as the updated estimates of abundance shown in Table 2.7-3.

UCR steelhead populations have generally increased in abundance since the 1990s, but have experienced recent reductions (Table 2.7-3), primarily due to poor ocean conditions. These conditions (e.g., temperature and salinity, coastal food webs), appeared to be more favorable to steelhead survival and adult returns in 2018, but were still impacted by recent warming trends.

2.7.1.2 Status of Critical Habitat

NMFS (2005b) designated critical habitat for UCR steelhead to include all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to its confluence with the Okanogan River (50 CFR 226.212(n)). Of 32 designated HUC5[244] watersheds in the Columbia River and the Okanogan, Similkameen, Methow, Entiat, Wenatchee, Lower Crab, and Upper Columbia/Priest Rapids subbasins, NMFS (2005b) gave 25 a high, six a medium, and one a low rating for their value to the conservation (i.e., recovery) of the species. All mainstem Columbia and Snake River reaches, including those in the Columbia River estuary, were given high ratings

[244] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watershed throughout the country. A HUC is a five-unit (5 two-digit numbers) code. Examples are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the Wenatchee Basin, Washington.

because they connect every population with the ocean and are used by rearing/migrating juveniles and migrating adults.

The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features, NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b), as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.
- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These

features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.

- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case of freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The complex life cycle of UCR steelhead gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead rely on limited energy stores to migrate, mature, and spawn.

Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005b).

In the following paragraphs, we discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary Recovery Domains.

2.7.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia Recovery Domain for UCR steelhead. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Critical habitat throughout much of the Interior Columbia Recovery Domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas. Restoration activities addressing tributary habitat quality and complexity, tributary and mainstem migration barriers, water quality, and excessive predation have improved the baseline condition for PBFs in some locations.

UCR steelhead have lost access to large blocks of their historical habitat. The construction of Chief Joseph and Grand Coulee Dams blocked fish access to historical habitat in the upper Columbia River and its major tributaries. Many smaller dams, and some temporary dams, were also built on tributaries at this time without fish passage facilities and had the same effects, though on much smaller scales. The loss of this historical habitat significantly reduced the spatial structure that was once available to the species.

Construction of other large hydropower and water storage projects associated with the CRS further affected salmonid migratory conditions and survival rates. As noted above, the production of UCR steelhead was especially impacted by the development of four major Federal dams and reservoirs in the mainstem lower Columbia River and five PUD-owned dams in the middle Columbia River migration corridor.

Hydrosystem development also modified natural flow regimes, resulting in warmer late summer and fall water temperatures. Changes in fish communities led to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams such as turbines and juvenile bypass systems have also killed some outmigrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented improvements in the juvenile and adult migration corridors, including 24-hour volitional spill, improved surface passage routes, improved juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

Many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain are over-allocated, with more allocated water rights than existing stream flow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a limiting factor for UCR steelhead (UCSRB 2007).

Many stream reaches designated as critical habitat are listed on the Oregon and Washington Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures (Spence et al. 1996). Furthermore, contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste are common in some areas of critical habitat. They can negatively impact critical habitat and the organisms associated with these areas.

2.7.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat also has been designated for UCR steelhead in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained the dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed that restrict the position of tributary confluences.

Over time, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of the historical variability in mainstem flows in the lower river through storage and release operations at upstream reservoirs may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has reduced the delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The combined effect of these changes is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs, and thus the conservation value of critical habitat for UCR steelhead within the action area, are discussed in more detail in the Environmental Baseline section, below.

2.7.1.3 Climate Change Implications for UCR Steelhead and Critical Habitat

One factor affecting the rangewide status of UCR steelhead and aquatic habitat is climate change. The USGCRP[245] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[246] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, earlier emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003, Crozier et al. 2008a, Martins et al. 2012, Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change

[245] http://www.globalchange.gov

[246] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

and the synergy among interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead include:

- Direct effects of increased water temperatures on fish physiology.
- Temperature-induced changes to stream-flow patterns can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.
- Alterations to freshwater, estuarine, and marine food webs that alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity has changed the abundance and productivity of fish resources.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Crozier et al. (2019) assessed UCR steelhead as having high vulnerability to the effects of climate change based on an analysis of the DPS's sensitivity (high), climate exposure (high), and adaptive capacity (moderate).[247] Overall sensitivity for UCR steelhead was ranked high, in part because of a high score for the adult freshwater stage. Populations experience peak summer temperatures during adult migration and pre-spawn holding (Wade et al. 2013). Exposure to stream temperature change was also ranked high, indicating a high combined life stage vulnerability.

Although detailed information on the ocean distribution of UCR steelhead is not available, past studies suggest that steelhead from Pacific coastal systems generally occur in the Gulf of Alaska and the subarctic waters south of the Aleutian Islands (Light et al. 1989). Abdul-Aziz et al. (2011) developed spatially explicit representations of open ocean thermal habitat for steelhead. They found that under a multimodel ensemble average of climate model outputs using the A1B emissions scenario, summer habitat area declined by 36 percent for the 2080s, with the largest habitat losses in the northeast Pacific Ocean. Wintertime habitat area losses were 2 percent, with

[247] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results

reductions at the southern end of the historical range largely offset by habitat area gains in the Bering Sea and Sea of Okhotsk.

Whether a general northward and westward displacement of the most frequently observed thermal open ocean habitat will have substantial impacts on the life-cycle, productivity, or spawning distribution of these steelhead is not known. A recent study of smolt-to-adult survival trends found similar patterns in annual marine survival for stocks within regional groupings for Puget Sound, British Columbia, and coastal Washington and Oregon (Kendall et al. 2017). Such patterns suggest that marine/estuarine factors associated with the point of ocean entry may be more important determinants of year-class survival for steelhead than general conditions in the adult ocean range.

This DPS scored moderate to high in exposure to flooding, stream temperature, and summer water deficit. However, the sensitivity of its early life history and the juvenile freshwater stage was rated low because stream temperature and flows are currently within tolerance limits. Sensitivities were low to moderate for the estuary stage. Exposure was ranked high for sea surface temperature, and low for exposure to ocean currents, upwelling, and sea level rise. Sensitivity for this DPS was ranked as moderate for the marine stage.

The overall rating for adaptive capacity for UCR steelhead was moderate. There may be some latitude for shifting adult return and upstream migration timing to avoid peak late summer temperatures (Robards and Quinn 2002), but the consequences of such shifts in timing are not known. The mid-to-lower reaches in each population are subject to annual high stream temperatures and summer water deficits, and there are limited opportunities to shift juvenile rearing patterns. There may be some opportunities to expand summer rearing and overwintering to habitat areas upstream, but the amount of suitable habitat is limited compared to the potential loss of downstream reaches.

2.7.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima are likely to be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce fitness for salmonids, including UCR steelhead (Beechie et al. 2013, Wainwright and Weitkamp 2013, Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a, Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are others where it is detrimental (Sykes et al. 2009, Whitney et al. 2016).

2.7.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snowpack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location (Crozier et al. 2008b, Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, by the rate of the increases. The effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b, Beechie et al. 2013). However, river flow is already becoming more variable in many rivers and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely that this increasingly variable flow is detrimental to multiple salmon and steelhead populations in the Columbia River basin.

The effects of climate change on stream ecosystems are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes are likely to lead to shifts in the distributions of native species and facilitate establishment of exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016, Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.7.1.3.3 Estuarine Effects

In estuarine environments, the two greatest concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013, Limburg et al. 2016). Estuaries will be affected directly by sea-level rise; as sea levels rise, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010, Wainwright and Weitkamp 2013, Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006, Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict inward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species and life history types are highly reliant on estuarine wetlands for rearing, many populations use them extensively (Jones et al. 2014). Others, such as yearling UCR steelhead, benefit from the influx of prey from the floodplain to the mainstem migration corridor (Johnson et al. 2018, PNNL and NMFS 2018, 2020).

2.7.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010, Asch 2015, Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years. For example, range extensions were documented in many species from southern California to Alaska during unusually warm water associated with the marine heatwave known as “the blob” in 2014 and 2015 (Bond et al. 2015, Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002, Fisher et al. 2015). The potential for UCR steelhead to shift their distribution north was discussed above. The frequency of extreme conditions such as those associated with marine heatwaves or El Niño events is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015, Rehage and Blanchard 2016). While it is certain that these effects will occur, current models cannot predict the composition or outcomes of future trophic interactions. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm ocean conditions, suggesting that, at a minimum, prey availability and prey quality, “bottom-up” drivers of growth and survival, may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem[248] (Bograd et al. 2009, Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014, Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unaffected by climate change, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean (Tomaro et al. 2012), and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

[248] The California Current moves southward along the western coast of North America, beginning off southern British Columbia and ending off the southern Baja California Peninsula.

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007, Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in Alaska salmon productivity and survival (Mantua et al. 1997, Martins et al. 2012). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009, Martins et al. 2012). However, more recent information indicates that Alaska salmon, which have historically contrasted with southern populations by benefitting from warm phases of the PDO, no longer have a positive correlation with winter sea-surface temperature (Litzow et al. 2018) and are more synchronized with southern populations (Ohlberger et al. 2016). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon is likely to be its influence on marine food webs, especially at the lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015, Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.7.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change in general, including in the Pacific Northwest. The indirect effects of climate change are also uncertain, including whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013, Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will involve impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning that some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycles. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is less certain leading to a range of potential future outcomes.

2.7.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For UCR steelhead, we focus our description of the environmental baseline on where UCR steelhead juveniles and adults are most exposed to the effects of the proposed action. We also consider the broader action area, including tributary habitat, because the Action Agencies propose to conduct habitat restoration actions and because these areas provide an important context for understanding the effects of the proposed action.

To determine the upstream extent of UCR steelhead distribution and thus most exposure to the effects of the proposed action, we reviewed data at each dam to examine the potential for UCR steelhead presence. The area of greatest exposure to the effects of the proposed action is the Columbia River from the mouth and plume[249] up to Chief Joseph Dam with respect to actions that affect flow. The area includes tributaries and their confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions in the Columbia River basin.

2.7.2.1 Mainstem Habitat

Mainstem habitats in the middle and lower reaches of the Columbia River have been substantially altered by basinwide water management operations, the construction and operation

[249] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., smallmouth bass, walleye, channel catfish, invertebrates, etc.), and other human activities that have degraded water quality and habitat.

2.7.2.1.1 Seasonal Flows

On the mainstem of the Snake and Columbia Rivers, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.7-3). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

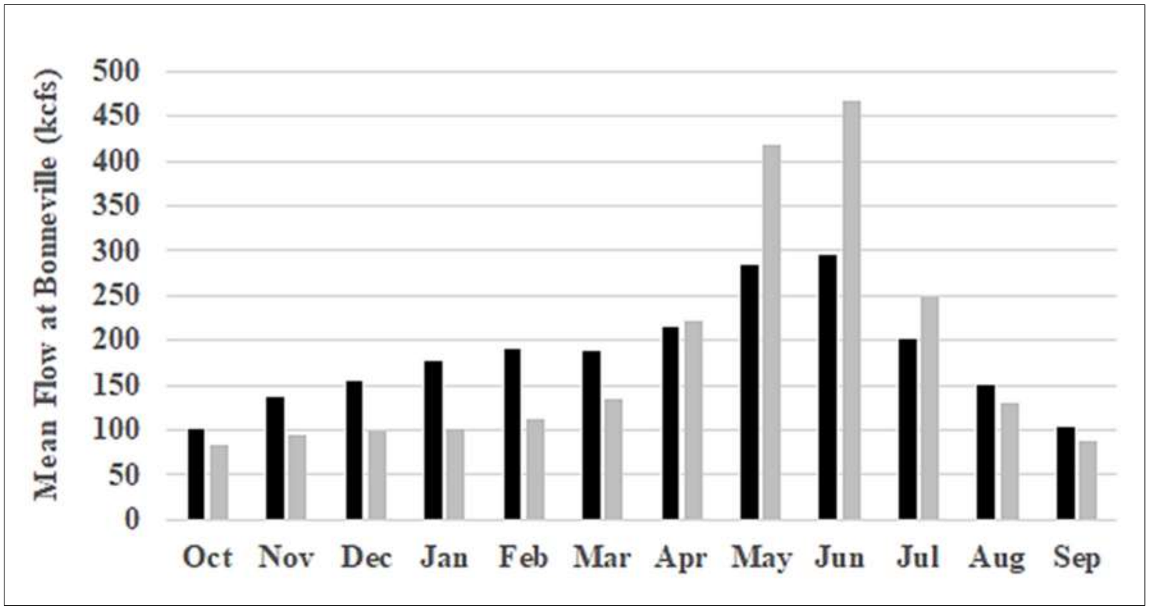

Figure 2.7-3. Simulated mean monthly flows for the Columbia River at Bonneville Dam under “current” (black) and “unregulated” (gray) conditions. “Current” flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. “Unregulated” flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[250] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year (Table 2.7-4). This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et

[250] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile UCR steelhead and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

Table 2.7-4. Seasonal flow objectives and planning dates for the mainstem Columbia and Lower Snake Rivers. NA indicates that there is not a flow objective for the season at these projects.

Location	Spring		Summer	
	Dates	Objective (kcfs)	Dates	Objective (kcfs)
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100[a]	6/21 to 8/31	50 to 55[a]
Columbia River at McNary Dam	4/10 to 6/30	220 to 260[a]	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 to 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160[b]	NA	NA

[a] Objective varies based on actual and forecasted water conditions.

[b] Objective varies according to water volume forecasts and is for chum salmon (spawning period is approximately November 1 through December and protection flow objectives are based on redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

Seasonal flow objectives for improving the migration and survival of spring and summer juvenile migrants are based on water supply forecasts; however, mean seasonal flows in the past did not always achieve the flow objectives when measured as a seasonal average flow. From 1998 to 2019, seasonal spring flow objectives were met or exceeded during 81 percent of years at McNary Dam and during 48 percent of years at Lower Granite Dam. For the years when the spring flow objectives were not met, the average seasonal flow was 88 percent of the spring flow objective at McNary Dam and 78 percent of the spring flow objective at Lower Granite Dam. Across all years, the average percentage of the spring flow objective obtained was 113 percent at McNary Dam and 101 percent at Lower Granite Dam. Achieving these seasonal flow objectives provides multiple benefits for smolts in the migration corridor, estuary, and plume. Higher spring flow helps reduce fish travel time, increases juvenile access to shallow water habitat along the river banks, increases the flux of invertebrate prey to shoreline habitat, increases turbidity (which can reduce predation on juvenile migrants), and increases the size of the Columbia River plume, which is a key transition corridor for smolts to the nearshore ocean environment. Conversely, when seasonal flow objectives are not met, juvenile survival may be reduced via these same pathways of ecological effects.

From 1998 to 2019, summer flow objectives were met or exceeded during 14 percent of years at McNary Dam and during 18 percent of years at Lower Granite Dam. For the years when the summer flow objectives were not met, the average seasonal flow was 74 percent of the summer flow objective at McNary Dam and 66 percent of the summer flow objective at Lower Granite Dam. Across all years, the average percentage of the summer flow objective obtained was 85 percent at McNary Dam and 79 percent at Lower Granite Dam. The benefits provided by attaining summer flow objectives, and potential impacts associated with not meeting them, are the same as those previously described for the spring flow objectives.

Recommendations on when to manage flows for the benefit of juvenile passage are made by the TMT during the juvenile migration season. These recommendations are informed by the status of the juvenile migration, water supply forecasts, river flow conditions, and river flow forecasts during the juvenile migration season.

2.7.2.1.2 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult UCR steelhead is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of UCR steelhead, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead survival is a concern; because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges from cities and industries.
- Climate change.

Temperatures in the middle Columbia River are affected by Grand Coulee Dam, completed in 1942. Thermal inertia from the large mass of water in the reservoir (total storage capacity of 9.6 million acre-feet, active capacity of about 5.2 million acre-feet) results in delayed warming in the spring (cooler temperatures) and delayed cooling in the late summer and fall (warmer temperatures). Even in the extremely warm year of 2015, the average temperature of Grand Coulee outflows was less than 68°F (Figure 2.7-4) (NMFS 2016d), indicating little risk from this environmental parameter to spring migrating UCR steelhead smolts. However, warmer August and September temperatures, though not exceeding the State of Washington’s temperature standard, would increase the risk of negative effects, such as pre-spawning mortality and reduced gamete viability, to summer migrating adults.

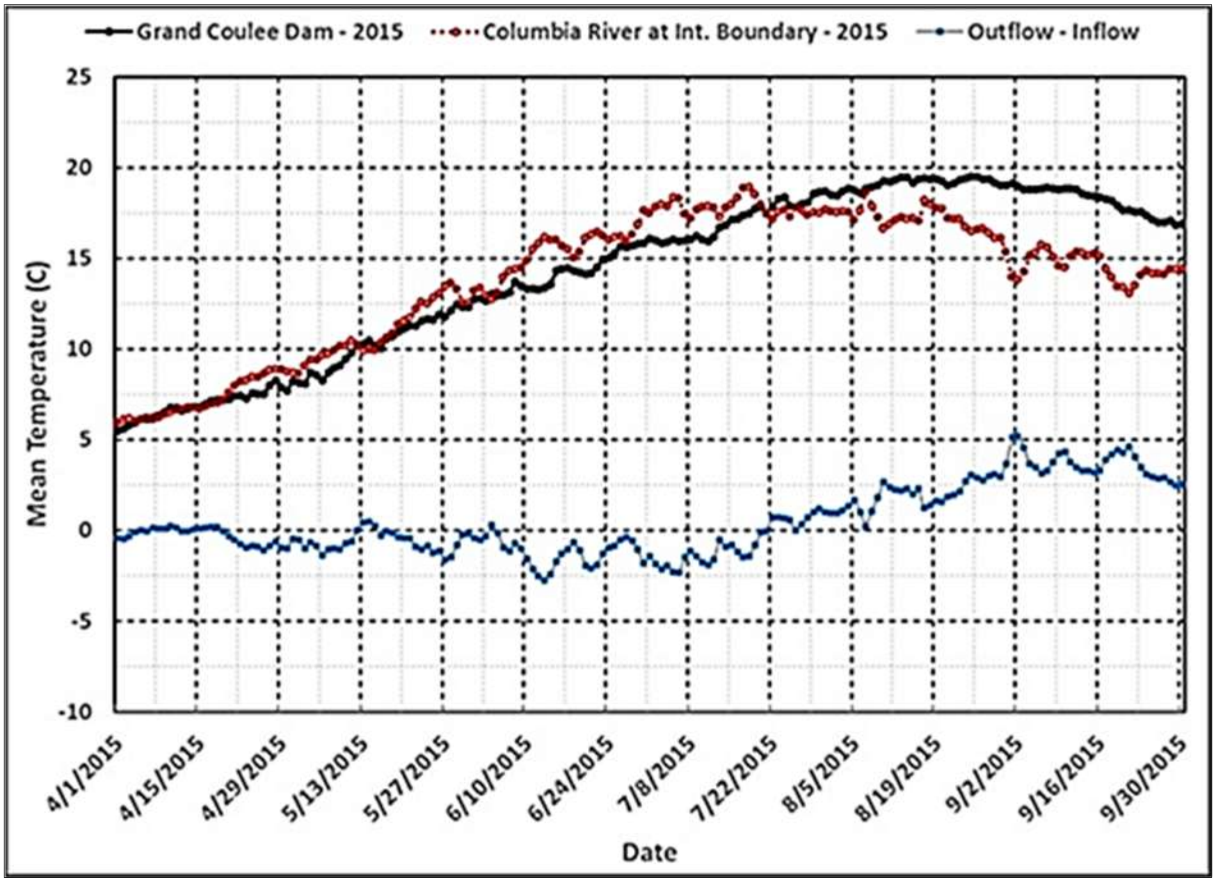

Figure 2.7-4. Outflow temperatures at Grand Coulee Dam compared to upstream Columbia River temperatures at the international boundary. Blue line indicates the difference (inflow – outflow) in temperature. Source: BOR Hydromet Data in NMFS 2016a.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period from 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the run-of-river dams and found three notable differences between the current and the unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the middle and lower reaches of the Columbia River likely have similar effects.

These hydrosystem effects (which stem from both upstream storage projects and run-of-river mainstem projects) continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broadscale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and at temperature extremes, survival.

The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the middle and lower Columbia River during spring. Exposure to elevated temperatures in the lower Columbia River from its mouth to its confluence with the Snake River, is greatest for adult UCR steelhead migrating in the late summer when water temperatures are highest (Keefer et al. 2016, Keefer and Caudill 2017).

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with Federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995a). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam, except The Dalles Dam. The FERC-licensed Wanapum Dam in the middle Columbia River reach also uses these structures to control TDG. Biological monitoring shows that the incidence of observable GBT symptoms in both migrating smolts and adults is between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[251] Under recent operations (2008 to 2019), exposure to elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June, affecting most UCR steelhead smolts. Monitoring data from 1998 to 2018 indicate that

[251] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

TDG did not increase instantaneous mortality rates for juvenile steelhead in the CRS (CSS 2019).

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

Sediment Transport

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.7.2.1.3 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of UCR steelhead in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[252] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted “losses” of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[253] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be “pass through” waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters are or may be discharged at a level that “will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard.” EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the

[252] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[253] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river.

effluent, toxicity to aquatic life, and, where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.7.2.1.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adults that are migrating past the dams or overwintering within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Few juvenile UCR steelhead have been affected by these activities, because they predominantly migrate from April to June.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult UCR steelhead has likely resulted in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes have minimized the impacts.

2.7.2.1.5 Adult Migration/Survival

Adult UCR steelhead migrate from the ocean, upstream through the estuary, and pass between seven and nine mainstem dams and reservoirs (four of these are CRS dams) to reach their spawning areas. Factors that affect the survival rates of migrating adults include fish condition, harvest (either reported or unreported), dam passage (adults must find and reascend ladders if they accidentally fall back over the spillway), straying (either naturally or as a result of impaired homing stemming from other factors), pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish (NMFS 2008a, Keefer et al. 2016, Keefer and Caudill 2017).

PIT-tag detectors placed in adult ladders at the mainstem dams provide a unique ability to monitor the upstream survival of adults that were tagged as juveniles.[254] Starting with the number of adults detected at Bonneville Dam, minimum survival estimates can be derived to detectors at upstream dams. These survival estimates are adjusted for reported harvest and the expected rate of straying of natural-origin adults. Figure 2.7-5 depicts adjusted survival rates from Bonneville to McNary Dams (three reservoirs and dams in the lower Columbia River) during 2009 to 2018, years that include recent hydropower operations and harvest rates within the "zone 6" fishery (as designated in the *U.S. v. Oregon* Management Agreements). Figure 2.7-5 also shows minimum estimated survival rates from McNary to Priest Rapids Dam (McNary Reservoir and the free-flowing Hanford reach of the Columbia River) or to Wells Dam (McNary to Priest Rapids Dam and an additional four reservoirs and dams) for fish released as juveniles upstream of Wells Dam (2008 to 2017). No adjustments were made for harvest or survival for estimates upstream of McNary Dam. For the McNary to Wells reach, a statistical model (the Cormac Jolly Seber method) was used to estimate survival rates because of low detection efficiency at Rock Island Dam (other Columbia and Snake River dams typically have detection efficiencies approaching 100 percent).

As shown in Figure 2.7-5, the 10-year average minimum survival estimate for UCR steelhead from Bonneville to McNary Dam is 92.2 percent (range of 87.6 to 96.8 percent).[255] The minimum survival estimate for UCR adult steelhead released upstream of Wells Dam as juveniles was 95.3 percent (range of 84.8 to 98.3 percent) from McNary to Priest Rapids and 95.6 percent (range of 91.0 to 98.5 percent) from Priest Rapids to Wells Dam.[256]

[254] Using only known origin fish that were NOT transported as juveniles; adjusted for reported harvest and natural stray rates.

[255] These minimum survival estimates are often termed conversion rates. Conversion rates close to, or higher than, 100 percent are possible if estimates of harvest rates (or natural rates of straying) are higher than what actually occurred in a given year (biased high). Conversely, if harvest rates are underestimated, the resulting conversion rate estimates would be biased low.

[256] As a condition of their Federal license, all PUDs must evaluate adult survival at 10-year intervals to ensure that standards are maintained. All three mid-Columbia PUDs (Grant, Chelan and Douglas) have achieved adult survival standards for UCR steelhead.

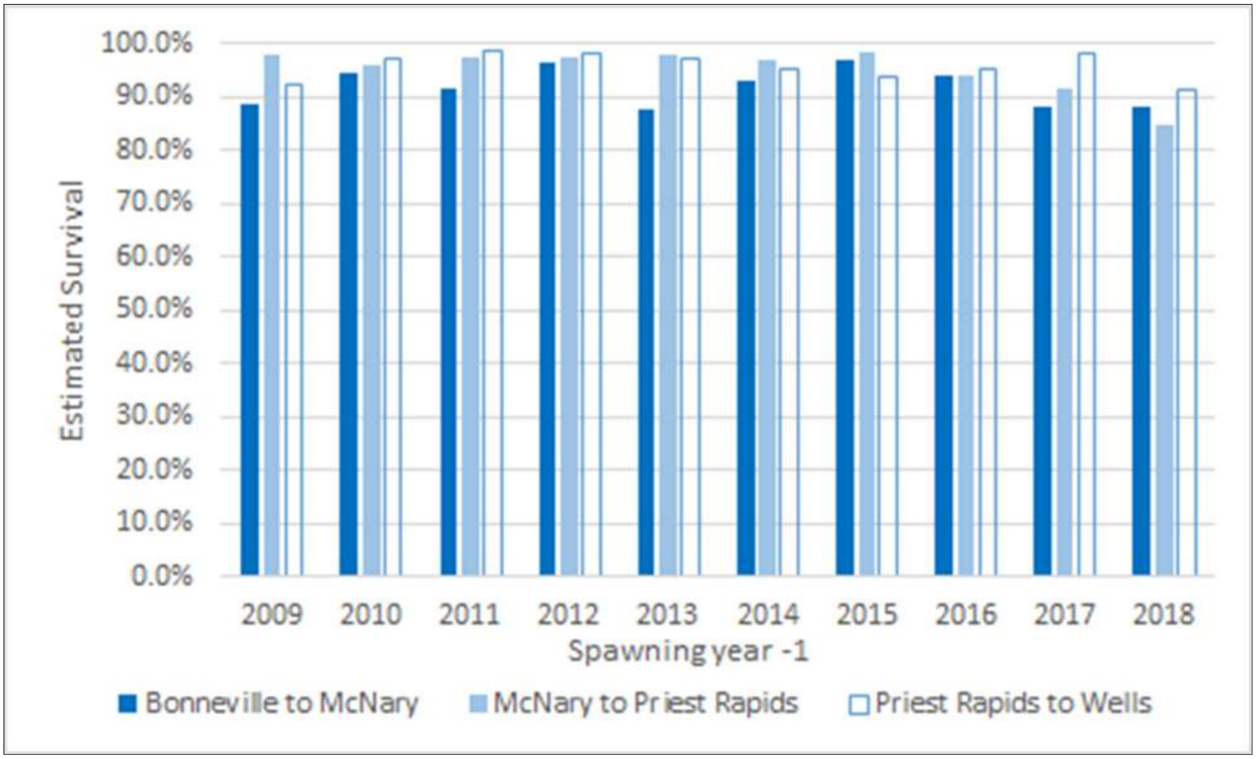

Figure 2.7-5. 2010–2018 survival estimates from Bonneville to McNary Dam (of known-origin PIT-tagged adult UCR steelhead, natural- and hatchery-origin combined); McNary to Priest Rapids Dam; and Priest Rapids to Wells Dam (of known-origin PIT-tagged UCR adult steelhead released upstream of Wells Dam as juveniles). Bonneville to McNary reach is corrected for straying and harvest. Priest Rapids to Wells reach was estimated using the Cormack Jolly Seber method due to low PIT tag detection efficiency at Rock Island Source: NMFS, using data from PITAGIS.

During the peak of the UCR steelhead adult migration in July and August, solar radiation heats reservoir surface waters, which can lead to high temperatures and temperature differentials between the bottom and top sections in a fish ladder. Ladder temperatures exceeding 68°F and differentials greater than 1.8°F have been demonstrated to delay passage for steelhead and Chinook salmon at the CRS dams in the Lower Snake River (Caudill et al. 2013). As temperature differentials increased, time required for passage increased; a temperature differential of 5.4°F increased the ladder passage time for steelhead at Lower Granite Dam by a factor of 2.4 to 2.5 compared to no temperature differential. Caudill et al. 2013 noted that the increased travel time, increased thermal exposure, and related physiological stresses could reduce successful migration to natal tributaries. Ladder temperatures commonly exceed 68°F, and ladder differentials regularly exceed 1.8°F while UCR steelhead are migrating (McCann 2018). During the most extreme summer days, ladder temperatures in CRS dams can exceed 75.0°F, and ladder differentials can exceed 4.5°F (FPC 2019). Fish ladder–cooling structures have been installed at Little Goose and Lower Granite Dams that pump colder water from deeper in the reservoir into the fish ladder to reduce ladder temperature differentials. There are currently no structures to reduce ladder temperatures at the other CRS dams, but research has identified that during the warmest months, cooler water is available that could be pumped into ladder exits to reduce high temperatures and ladder differentials (Lundell 2019).

CRS-related mortality of downstream migrating kelts is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 60.4 and 67.3 percent survived from the McNary forebay to the lower Columbia River (RM156) and Bonneville Dam face, respectively. It is important to note that in this study, only fair and good condition kelts were selected for tagging, and these survival rates cannot be applied to poor condition kelts. Based on this limited information, up to 40 percent of UCR kelts arriving at McNary Dam are lost upstream of Bonneville Dam. These data represent total mortality of outmigrating kelts and do not distinguish between mortality caused by the existence and past operation of the CRS or other factors (i.e., condition of fish, natural mortality rates, etc.). It is not technically possible to provide separate estimates of these components.

2.7.2.1.6 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and nonnative species that are predators, competitors, or food sources for migrating juvenile steelhead. The travel times of migrating smolts are increased through the reservoirs, increasing exposure to both native and nonnative predators (see Section 2.7.2.6), and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spill bays, or surface passage routes) (NMFS 2008a, b).

However, based on data summarized in Zabel (2019) and Widener et al. (2020), overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1998, when the species was listed. The improved survival correlates with improved structures and operations and predator-management programs at the Corps' and FERC-licensed mainstem projects (24-hour volitional spill, surface passage routes, improved juvenile bypass systems, predator-management measures, etc.) (UCSRB 2007).

Table 2.7-5 depicts the hydrosystem spillway operations for the five mid-Columbia PUD-owned dams (Douglas, Chelan, and Grant County). Table 2.7-6 depicts the FOP for spring spill during 2017, 2018, 2019, and 2020 at the Action Agency-operated dams in the lower Columbia River. There was a substantial increase in spill over the dam spillways in the spring during 2018 in response to a court order requiring additional spill. Spill levels in 2019 and 2020 using flexible spill, as proposed by the Action Agencies and consulted upon in the 2019 CRS biological opinion, were also higher than spill in 2017 at most projects. The spillways represent just one of several routes of passage through the dams. For example, the Wells project is constructed as a hydropower combine and utilizes modified spillway bays to efficiently pass juvenile salmon and steelhead past the project in a non-turbine route of passage.

Table 2.7-5. Summary of recent spring spill levels (percent of project outflow or kcfs) at mid-Columbia PUD projects.

Project	Recent Spring Spill Operations (Day/Night)[257]
Wells	7% or more Uses of up to five surface bypass entrances (modified spillway bays)
Rocky Reach	9%
Rock Island	10%
Wanapum	20 kcfs
Priest Rapids	27 kcfs

Table 2.7-6. Summary of 2017, 2018, 2019, and 2020 Fish Operations Plan spring spill levels (April 10 to June 15) at lower Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flex Spill	2020 Flex Spill
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)
John Day	**April 10–April 28:** 30%/30% **April 28–June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 40% Performance Standard (8 hours per day)	40%/40%
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)	120% TDG gas cap (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)	125% TDG gas cap up to 150 kcfs (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)

[1] Spill operations are described as percent of project outflow or kcfs.

Performance standards testing at the mid-Columbia PUD FERC-licensed projects indicates that recent average juvenile survival rates to Priest Rapids tailrace are about 78.1 percent for juveniles from the Okanogan and Methow Rivers (five reservoirs and dams), 81.0 percent for juveniles from the Entiat River (four reservoirs and dams), and 84.5 percent for juveniles from

[257] The five Mid-Columbia PUD projects must achieve a minimum 91 percent combined adult and juvenile salmonid survival performance standard at each project (dam and reservoir); translating to approximately 98 percent adult survival and 93 percent juvenile survival per project.

the Wenatchee River (three reservoirs and dams).[258] This equates to average per project (reservoir and dam) juvenile survival rates of 93 to 96 percent. Using PIT tags, survival from all hatchery release sites to McNary Dam averaged 41.4 percent over the last 16 years (Zabel 2019 and Widener et al. 2020).

Zabel (2019) and Widener et al. (2020) estimate that hatchery-origin juvenile steelhead survival rates from McNary to Bonneville Dam (three reservoirs and dams) averaged 77.8 percent from 2010 to 2019. The reduced survival rates in the lower Columbia River in 2015 (57 percent) and 2016 (49 percent), were likely influenced by increased predation by Caspian terns displaced from Crescent Island to the Blalock Islands in John Day Reservoir (Roby et al. 2016). The estimated survival rate in 2018 was 116.1 percent (standard error of 18.6 percent), indicating that survival was likely high, but the error around the estimate was also high.[259] This estimate is the highest observed since 2003, but also had the second highest estimated standard error. For comparison, the 2017 estimate was 96.4 percent (standard error of 18.8 percent, the highest estimated since 2003). The estimated survival rate in 2019 was below average (60.6 percent) with relatively small standard errors (4.7 percent).

Together, these survival rates represent a substantial improvement in migration conditions and survival rates for juvenile UCR steelhead migrating through the impounded reaches of the middle and lower Columbia River, compared to the 1970s to the mid-2000s (NMFS 2008a), which has the potential to increase the overall productivity of the populations and the abundance of returning adults. However, substantial mortalities (stemming from both the existence and operation of the mainstem Federal and FER-licensed dams, predators [both native and non-native], and natural mortalities) continue to occur in the mainstem Columbia River.

2.7.2.1.7 Transportation

Juvenile fish transport has been used for mitigation in the CRS since 1981 (Baxter et al. 1996). At dams with juvenile bypass systems, turbine intake screens divert smolts away from turbine units and into a system of channels and flumes.[260] At dams with transportation facilities, diverted fish may be bypassed into the tailrace below the dam or collected in raceways where they can be loaded onto barges or trucks, transported below Bonneville Dam, and then released into the lower Columbia River to continue migrating to the ocean. The only dams in the CRS currently

[258] As a condition of their Federal license, all PUDs must evaluate juvenile survival at 10-year intervals to ensure that standards are maintained; this requires a monitoring program. All three mid-Columbia PUDs (Grant, Chelan and Douglas) have achieved juvenile survival standards for UCR steelhead.

[259] Survival estimates higher than 100 percent are possible given the extremely large variability in the estimate. They are obviously not possible in reality and would be best interpreted as a high survival rate, likely approaching 100 percent. To calculate the 2008 to 2017 average, 2008 was not included (as too few detections were observed to make reasonable survival estimates) and 1.00 was used for the survival value in 2012, rather than the 1.069 estimated value.

[260] All of the powerhouses at the four lower Columbia River mainstem dams have juvenile bypass systems, with the exception of The Dalles Dam and Bonneville Dam, Powerhouse 1; Rocky Reach Dam is the only mid-Columbia PUD project which has a conventional screening system on some of its turbine units.

used for collection are Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam in the lower Snake River. A few late-migrating UCR steelhead were transported from McNary Dam between 1985 and 2012, after which all transport from McNary Dam ceased based on a recommendation from NMFS.

2.7.2.1.8 Mid-Columbia Public Utility District Projects in the Mainstem Columbia River

In 1998 to 2004, two PUDs (Chelan County and Douglas County) worked cooperatively with various state and Federal fisheries agencies, including NMFS, USFWS, WDFW, three Native American tribes, and an environmental organization, American Rivers, to develop the first hydropower HCPs for salmon and steelhead. Under the HCPs, the two PUDs commit to a 50-year program to ensure that their projects have no net impact on UCR spring-run Chinook salmon and UCR steelhead. This will be accomplished through a combination of fish bypass systems, spill at the hydropower projects, off-site hatchery programs and evaluations, and habitat restoration work in tributaries to the Columbia River in the affected reach. The PUDs must meet minimum targets for either combined juvenile and adult survival or for juvenile-only survival through their reservoirs and past their dams. The minimum combined survival target is 91 percent, and juvenile-only survival target is 93 percent. The PUDs have met or exceeded those levels for all spring migrating salmon and steelhead species at the Rocky Reach, Rock Island, and Wells Development hydropower projects. Subsequently, FERC completed consultation on the renewal of the FERC license for the Wells Development Project (Douglas PUD) that carries those same commitments forward. Also, in the middle Columbia reach, FERC completed consultations on licenses to operate for two Grant PUD projects in 2008: Wanapum Development and Priest Rapids Development. The licenses and ESA consultations required improved facilities and operations to improve conditions for migrating fish, habitat restoration activities, and improved hatchery operations and are generally consistent with actions identified in the Recovery Plan.

2.7.2.2 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect natural populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

The Leavenworth National Fish Hatchery Complex consists of three large facilities, one of which, the Winthrop National Fish Hatchery, produces UCR steelhead. These programs were authorized in 1937 as part of the Grand Coulee Fish Maintenance Project to compensate for the loss of access to historical spawning and rearing habitat with the construction of Grand Coulee Dam. At the time, it was estimated that 85 to 90 percent of the adults counted at Rock Island Dam had originated upstream of Grand Coulee Dam. Until recently, these programs released co-mingled upriver stocks into the Wenatchee, Entiat, and Methow subbasins. Adults were collected at Priest Rapids and later at Wells Dam, and the smolts they produced were released into various tributaries. These programs also released stocks that originated in the lower Columbia River basin.

Under settlement agreements and stipulations developed through FERC processes and related biological opinions, the three mid-Columbia PUDs also fund hatchery programs within the upper Columbia River basin. Although earlier programs at the Wells and Chelan hatcheries were intended to provide fish for harvest, under current settlement agreements, the objective for the hatchery component of these FERC-licensed projects is to contribute to the rebuilding and recovery of natural populations in their native habitats, while maintaining population genetic and ecological integrity and supporting harvest. In 1997, WDFW began a hatchery program for the Wenatchee subbasin using locally collected broodstock. Programs in the Methow subbasin use fish that return to the Methow River for broodstock, and the program in the Okanogan subbasin is in the process of transitioning to using fish from the Okanogan River for broodstock.

The Confederated Tribes of the Colville Reservation (CTCR) have operated a kelt reconditioning program in the Okanogan subbasin in the past. This program is currently permitted under a 4(d) rule for the CTCR's Tribal Resource Management Plan (NMFS 2017j).

Another kelt reconditioning program, the Upper Columbia Kelt Reconditioning Program, has been operated by the Yakama Confederated Tribes for the past 10 years to enhance the abundance and life-history diversity of naturally produced steelhead. This program plans to continue collecting 60 to 100 kelts and releasing 30 to 75 reconditioned kelts on an annual basis.

Genetic samples from the 1980s indicated little differentiation within populations in the UCR steelhead DPS. Hatchery operations are now aligned with the ESA recovery plan (UCSRB 2007) and are meant to ensure that levels of genetic effects will still allow natural populations to improve in productivity, abundance, and diversity and adapt to both current and changing environments (NMFS 2017j). Recent changes include a reduction in the hatchery programs funded by the PUDs starting in 2012 because of a revised calculation of their mitigation responsibility based on increased survivals through the PUD-owned dams. Reduced hatchery production has also reduced the number of hatchery-origin fish on the spawning grounds, potentially decreasing the genetic risk to the natural-origin populations. The programs have implemented the following additional reform measures:

- A change in water use at Leavenworth National Fish Hatchery has reduced water withdrawals from Icicle Creek, leaving more instream flow during summer months (NMFS 2017j).

- The Methow component of the Wells Complex steelhead program made changes in its broodstock by developing a genetically-linked program with Winthrop National Fish Hatchery to better link its hatchery fish to natural-origin steelhead. This is a critical step to recovery as these hatchery releases are responsible for a large proportion of the hatchery fish on spawning grounds in the Methow River (NMFS 2017j).
- Changes were made in the management of adult hatchery-origin steelhead returning to the Wenatchee River basin, which reduced pHOS and the resulting genetic risk to that population (NMFS 2016f).

NMFS has consulted on all the steelhead hatchery programs in the upper Columbia River basin (NMFS 2016f, 2017j, 2017m), and has concluded that they are not likely to appreciably reduce the likelihood of survival and recovery of the UCR steelhead DPS.

2.7.2.3 Recent Ocean and Columbia River Harvest

UCR steelhead are not targeted and are therefore rarely caught in ocean fisheries within the U.S. Exclusive Economic Zone and the coastal and inland marine waters of the west coast states (Washington, Oregon, and California) (NMFS 2018a).

The 2008 to 2017 *U.S. v. Oregon* Management Agreement allowed for the incidental take of up to 4.0 percent of the total run of UCR steelhead in non-Indian Columbia River fisheries. The range of estimated incidental take observed (2008 to 2017) was 1.1 to 3.3 percent, and averaged 1.9 percent. Incidental take associated with treaty harvest rates on A-Index steelhead was estimated to be about 8.1 percent.[261] Thus, average harvest rates for UCR steelhead have likely averaged about 10 percent in the zone 1 to 6 fisheries in the lower Columbia River. These harvest rates are substantial reductions compared to those that occurred before the 1990s.

NMFS signed the 2018 to 2027 *U.S. v. Oregon* Management Agreement based on information reviewed in both the final EIS and the associated biological opinion (NMFS 2018a). The agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho; ensures fair sharing of harvestable fish between tribal and non-tribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*; protects and conserves ESA-listed and non-listed species; and ensures that NMFS fulfills its treaty and trust responsibilities to Columbia River basin tribes.

[261] Fisheries managers classify steelhead into two aggregate or morphological groups, A-Index and B-Index, based on length of time spent in the ocean, size at return, and migration timing. A-Index steelhead predominately spend 1 year in the ocean, return to spawning areas beginning in the summer, and are assumed to be associated with low-to-mid-elevation streams throughout the interior Columbia River basin. B-Index steelhead begin migration in the fall and are generally larger than A-Index steelhead, with most individuals returning after 2 years in the ocean. A-Index steelhead occur throughout the steelhead-bearing streams in the Snake River basin and inland Columbia River, while B-Index steelhead only occur in the Clearwater River basin and the lower and middle Salmon River basin (NWFSC 2015).

In tributary areas of the upper Columbia River basin, steelhead fisheries operate under permit 1395 (NMFS 2003), permit 18583 (NMFS 2016f), and NMFS (2017j). Fisheries for non-ESA-listed fish also occur there and may have incidental impacts on UCR steelhead. These fisheries are covered under permit 1554 (NMFS 2008c) and NMFS (2017j). Annual ESA Section 10 permit reports show that the estimated take of UCR steelhead in mainstem and tributary fisheries above Priest Rapids Dam is small (Jording 2018). Reports indicate that, over the past 5 years, total incidental and directed mortalities in state fisheries above Priest Rapids Dam have averaged 87 adults and 540 juvenile UCR steelhead per year. In addition, the estimated maximum incidental mortality rates for all UCR steelhead handled by activities (i.e., hatchery program operation, tributary harvest, and research and monitoring) recently approved under the Colville Tribe's Tribal Resource Management Plan are as follows: 4 to 12 percent for Okanogan River basin activities (which encounter 60 percent of all returns to the Okanogan) and 5 to 12 percent of natural-origin, or 5 to 50 percent of hatchery-origin, steelhead handled at Wells Dam, with the chances of mortality increasing with number of fish handled and processed (NMFS 2017j). NMFS found that these fishery activities did not appreciably reduce the likelihood of survival and recovery of UCR steelhead.

These levels of exploitation are expected to continue and will continue to somewhat reduce the productivity and abundance of UCR steelhead.

2.7.2.4 Tributary Habitat

2.7.2.4.1 DPS Overview

Tributary habitat conditions in the subbasins within the UCR steelhead DPS (i.e., the Wenatchee, Entiat, Methow, and Okanogan subbasins) are good in high elevation reaches, but degraded in lower elevation stream reaches, particularly near valley bottoms (UCSRB 2007, 2014). The ability of tributary habitats in the Wenatchee, Entiat, Methow, and Okanogan subbasins to support the viability of UCR steelhead is generally limited by one or more of the following factors: 1) reduced stream complexity and channel structure, 2) reduced floodplain condition and connectivity, 3) degraded riparian conditions, 4) diminished stream flow, 5) impaired fish passage, 6) excess fine sediment, and 7) elevated summer water temperatures (UCSRB 2007). A 2014 synthesis report on the status of habitat in the Upper Columbia region (UCSRB 2014) found that the limiting factors of highest concern for the region are instream structural complexity, riparian conditions, bed and channel form, and increased sediment. The combination, intensity, and relative impact of these factors vary locally throughout each subbasin, depending on historical and current land use activities and natural conditions.

Human activities that have contributed to these limiting factors include dams, water diversions, stream channelization and diking, roads and railways, timber harvest, grazing, and urban and rural development (UCSRB 2015). Natural disturbance also has recently had a large effect on habitat in the Upper Columbia River basin. For instance, in 2014 the Carlton Complex fire, the largest fire ever recorded in Washington, burned approximately 253,377 acres. Fires are a natural disturbance that, from an ecological perspective, over time help facilitate the development and maintenance of the complex habitats needed by salmonids (Flitcroft et al. 2016, Bixby et al. 2015). However, in the near term, fires such as the Carlton Complex fire have and will likely continue to result in higher runoff rates, higher impacts (e.g., increased runoff and erosion leading to increased sediment load and streambed scouring) from rain and snow events, and increased sedimentation, with associated adverse effects on salmon productivity (UCSRB 2015).[262] Changes in precipitation and temperature have also influenced trends in habitat, with average temperatures increasing over the past three decades and precipitation decreasing, resulting in decreased snowpack and changes in runoff patterns and exacerbated low flow issues in some areas (UCSRB 2014).

In general, land use practices and regulatory mechanisms have improved from historical practices and regulations (UCSRB 2007, 2014). Roper et al. (2019), for instance, reviewed the status and trends of 10 stream habitat attributes to evaluate whether changes in Federal land management had altered the trajectory of stream habitat conditions in the interior Columbia River basin. They concluded that changes in management standards and guidelines in the 1990s are related to improved stream conditions, although they were not able to determine the precise magnitude of the changes. In addition, while new development appears to be a relatively minor factor in landscape change in the region (based on an assessment in a representative area by the State of Washington [UCSRB 2015]), ongoing development and land-use activities may continue to have negative effects.

Many habitat restoration actions have been, and are being, implemented in these subbasins through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies (UCSRB 2007, 2014; BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). The Action Agencies have been implementing tributary habitat improvement actions as part of mitigation for the CRS since 2007. These actions have included protecting and improving stream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. The actions are generally targeted toward addressing the limiting factors identified above (BPA et al. 2013, 2016, 2020). Cumulative metrics for these action types for UCR steelhead from the years 2007 to 2019 are shown in Table 2.7-7.

[262] For example, in August 2014, a heavy rain storm occurred across the Carlton Complex area and produced extensive run-off that led to severe hillslope erosion and debris flows in some areas that caused substantial channel scour, down cutting, bank erosion, and sedimentation. In addition, some road crossings failed as a result of the debris flows. Streams affected included fish-bearing streams and the mainstem Methow River, which received a substantial volume of fine sediment that caused high turbidity all the way to the Columbia River. Extensive fish mortality resulted in the Methow River and in Beaver and Frazer Creeks.

Table 2.7-7. Tributary Habitat Improvement Metrics: UCR Steelhead, 2007–2019 (BPA et al. 2020, McLaughlin 2020).

Action Type*	**Amount completed**
Acre-feet/year of water protected *(by efficiency improvements and water purchase/lease projects)*	44,309
Riparian acres protected *(by land purchases or conservation easements)*	428
Riparian acres improved *(to improve riparian habitat, such as planting native vegetation or control of noxious weeds)*	1,694
Miles of enhanced or newly accessible habitat *(by providing passage or removing barriers)*	248
Miles of improved stream complexity *(by adding wood or boulder structures or reconnecting existing habitat, such as side channels)*	41
Miles protected *(by land purchases or conservation easements)*	20
Screens installed or addressed *(for compliance with criteria or by elimination/consolidation of diversions)*	103

* Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have improved and will continue to improve habitat in the targeted populations as these projects mature, and that fish population abundance and productivity will respond positively. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions). Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

RME has been underway in this DPS to evaluate changes in habitat and fish populations as a result of habitat improvement actions. Available empirical evidence supports our view that these actions are improving habitat capacity and productivity, and that fish are responding. Below, we include limited examples of RME results specific to UCR steelhead, while Appendix A summarizes the scientific foundation of our determination, including relevant RME information from throughout the Columbia River basin and other lines of evidence that we considered regarding the effects of habitat improvement actions. It also discusses the complexities of evaluating the effects of habitat restoration on fish populations (see Appendix A; also see NMFS 2014a, Hillman et al. 2016, Griswold and Phillips 2018, ISAB 2018, Haskell et al. 2019).[263]

The best available scientific and technical information also indicates that there is additional potential to improve habitat productivity in these populations, and that additional improvements are needed to achieve recovery goals (UCSRB 2007, 2014, 2015; NMFS 2016d, UCRTT 2017). Density dependence has been observed in UCR steelhead populations (ISAB 2015), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stage and limiting factors, would be likely to improve overall population abundance and productivity.

An Upper Columbia Salmon Recovery Board assessment in 2014 concluded that the highest priority in the upper Columbia River region for increasing habitat productivity in degraded areas is to restore the complexity of the stream channel and floodplain function, where possible by promoting properly functioning geo-fluvial processes that control habitat diversity, instream flows, and water quality. Protection of existing stream flows in virtually all subbasins in the region is also important to maintaining biological productivity. In addition, these types of actions have the added benefit of increasing climate change resilience. Several planning processes have provided detailed assessments that identify the highest priority areas that are the most appropriate for reach-scaled restoration and protection programs. Within the past several years, habitat restoration has shifted toward larger-scale projects designed to address reach-based ecological concerns (UCSRB 2014).

More detail on tributary habitat conditions for the four populations that constitute this DPS is provided below.

2.7.2.4.2 Methow River Subbasin

In the Methow River subbasin, upper portions of major tributaries contain a high proportion of intact habitat. The primary habitat conditions in the Methow River subbasin that currently limit

[263] The goal of the tributary habitat program is to implement tributary habitat actions that address priority limiting factors and improve population abundance, productivity, spatial structure, and diversity. Measuring the effects of habitat restoration for fish and other aquatic and riparian biota is "one of the great challenges of river and stream conservation" (ISAB 2018). To draw conclusions about the effectiveness of tributary habitat improvements, we evaluated multiple lines of evidence, including knowledge of the basic relationships between fish and their tributary habitat, findings in the scientific literature about how changes in fish habitat affect fish populations, literature on the physical and biological effectiveness of tributary habitat improvement actions, correlation analyses, results from monitoring in the Columbia River basin designed to evaluate the effects of various actions on tributary habitat limiting factors and on salmon and steelhead response, and the results of life-cycle models. Those lines of evidence and our general conclusions are summarized in Appendix A.

abundance, productivity, spatial structure, and diversity of steelhead are mostly found in the middle and lower mainstem and lower portions of major tributaries. In these areas, road building, residential development, and agricultural practices have diminished stream complexity, wood and gravel recruitment, floodwater retention, and water quality, negatively affecting the ability of these habitats to support steelhead. Late summer and winter instream flow conditions also often reduce migration, spawning, and rearing habitat for salmonids. This is partly natural (a result of watershed-specific weather and geomorphic conditions) but is exacerbated by irrigation withdrawals (NMFS 2016d, UCRTT 2017).

Numerous partners, including Federal, tribal, and state agencies; utilities; private landowners; and nonprofit groups, have implemented a host of aquatic habitat enhancement actions in the Methow River subbasin over the past two decades. Overall, work in the Methow has involved over 50 partners and over 100 projects. Habitat improvement actions in this subbasin have been targeted at addressing limiting factors and have included protection and restoration of stream flow, screening of irrigation diversions, improving access to habitat, improving stream complexity and floodplain connectivity, and restoring riparian areas (BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). Actions have been based on increasingly detailed plans and assessments that identify limiting factors, ecological concerns, and action opportunities and priorities (see, e.g., UCSRB 2007, BOR 2008, UCRTT 2013, 2017). In addition, numerous, more detailed reach assessments have been completed at smaller spatial scales to identify sources of stream impairment, limiting factors, and specific action opportunities. Various entities have conducted reach assessments covering approximately one-fifth of the entire stream length in the Methow subbasin since 2008. This enhanced information base provides improved ability to identify actions that will provide the greatest benefit.

- The type and quantity of improvement actions have changed over time. Early projects, in the late 1990s, were primarily related to upgrading inadequate fish screens and screening unscreened diversions. Passage improvements included barrier removals associated with irrigation diversions in Beaver Creek in the mid-2000s that removed barriers to adult and juvenile fish. More recently, instream flow and habitat enhancement actions (e.g., improved instream complexity and floodplain and side-channel connectivity) have been the focus in the subbasin, primarily in the middle and upper mainstem Methow River, the Twisp River, the Chewuch River, and numerous smaller tributaries. Implementation of these habitat actions increased substantially beginning in 2008, with the largest number of actions implemented in 2013 through 2017. Since 2017, the number of enhancement actions implemented per year has decreased, but the complexity and size of recent actions has increased. Taken together these actions span a wide range of types, intensities, and sizes, and have resulted in a range of ecological responses (BOR 2019a). Best available science indicates that they have improved and will continue to improve habitat function for the Methow River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). Status and trends monitoring, action effectiveness monitoring, and development of ecological models in the basin have provided information to help understand the effects of the actions and inform development and implementation of more effective actions in the future. Some of the relevant results include the following:

- In the first year of monitoring following implementation of floodplain and channel habitat improvement actions in the Methow subbasin, restored sites experienced increased seasonal connectivity to the mainstem, increased overall habitat capacity, increased pool depths, and increased large wood cover, and each showed an increase in juvenile salmon and steelhead rearing densities compared to control sites (Martens et al. 2014). Subsequent years of post-treatment monitoring observed smaller increases in juvenile abundance (Hutcherson et al. 2018). Although not conclusive, these results are generally consistent with findings from other studies that have shown higher densities of Chinook and steelhead in treated versus untreated areas (BOR and BPA 2013, Polivka et al. 2015, Polivka and Claeson 2020).
- An evaluation of fish passage enhancement in Beaver Creek (a tributary to the Methow) demonstrated that passage was successfully restored to portions of Beaver Creek (Grabowski 2013, Weigel et al. 2013). Juvenile and adult steelhead migration were improved, and juvenile spring Chinook were found upstream where they had not been detected before. Adult recolonization occurred slowly following the barrier removal and was possibly affected by the 2011 flood and 2014 forest fire and subsequent flooding.
- Available data on fish use in the basin provide information on use patterns, trends, and potential responses to habitat enhancement efforts. The monitoring to date has yielded some results suggesting that enhancement efforts in the basin are improving salmonid survival and productivity, and the effects of enhancement actions on salmon and steelhead in the Methow are expected to become more apparent as additional years of post-implementation data are collected (BOR 2019a).

The Methow River population is currently at high risk and must achieve at least viable status to meet ESA recovery goals (UCSRB 2007). There remains additional potential for improvement in habitat productivity in this population (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and improvement is needed to restore habitat to levels that will support a viable population.

2.7.2.4.3 Entiat River Subbasin

While the majority of land in the Entiat River subbasin is under public ownership, the lower basin, including more than 70 percent of the stream length accessible to salmon and steelhead, is privately owned. Historical land uses of mining, water diversion, and timber harvest have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many areas. The primary habitat conditions in the Entiat River subbasin that currently limit steelhead include reduced stream channel complexity from logging, and flood control measures that straightened and removed large wood from the channel. These historical and ongoing activities have led to low instream habitat diversity, including few pools; lack of large wood; and disconnected side channels, wetlands, and floodplains. The result is a reduction in resting and rearing areas for both adult and juvenile steelhead throughout the Entiat River (NMFS 2016d, UCRTT 2017).

Restoration actions in this subbasin have included protection and restoration of stream flow, screening of irrigation diversions, improvements to passage barriers, improved stream channel complexity and floodplain connectivity, and riparian area protection and improvements (BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). These actions have been targeted at addressing limiting factors. Best available science indicates that the actions have improved and will continue to improve habitat function for the Entiat River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). As in other subbasins in the region, work in the Entiat is guided by geomorphic reach assessments, which cover over 90 percent of the anadromous habitat in the area.

Some habitat improvement actions in the Entiat River subbasin were implemented in 2012, 2014, and 2018 through 2019 under a structured and monitored approach through the Entiat River IMW. Reduced instream complexity was the primary concern limiting steelhead production in the lower 26 miles of the Entiat River. Current land uses (primarily agriculture, roads, and residential development) restricted habitat improvement options in this portion of the river, so an engineered approach was implemented to increase complexity, including adding rocks and large wood to the river, and reconnecting the floodplain by breaching levees where possible. So far, three of four planned rounds of habitat actions have been completed, affecting a majority of the targeted IMW reaches (additional implementation of actions is planned over the next several years in these reaches). The following are some of the relevant monitoring results:

- Habitat monitoring has shown a significant increase in the volume of wood in the Entiat River. No other habitat or geomorphic metrics have yet shown a response to the treatments, perhaps because insufficient time has elapsed for the response to occur (ISEMP/CHaMP 2015, 2016).
- Fish are using treated areas. For example, higher densities of juvenile steelhead use off-channel habitats compared to main channel locations within the Entiat River (Hillman et al. 2016). Polivka et al. (2015) found that juvenile steelhead were more abundant in improved pools than in untreated pools. Polivka and Claeson (2020) surveyed reaches of the Entiat River treated with engineered logjams and reaches without treatments to determine if restoration had increased habitat capacity. They found that the density of juvenile Chinook salmon and steelhead was 3.1 and 2.7 times greater, respectively, in treated habitat than in untreated habitat. To distinguish whether these density differences were actual increases in capacity rather than fish moving from poor habitat to good habitat, they compared density in unrestored habitat in both treated and untreated reaches. They found no differences for either species, confirming that the increased density in restored habitat units did not come from depletion of unrestored habitat in the same reach. Thus, they concluded that the restoration had increased the habitat capacity of the reach at the scale of pools created by engineered logjams.

- Researchers have not yet found significant fish population responses (Hillman et al. 2016), but it is challenging to detect a population response to improvement actions. In addition, the Entiat River has not yet experienced the high post-treatment flows needed to affect channel morphology as hypothesized. Furthermore, only 50 percent of the enhancement plan has been implemented to date (Hillman et al. 2016). However, these early results are encouraging because they show that habitat is changing and fish are using the improved habitat.

The Entiat River population is currently at high risk and must achieve at least viable status to meet ESA recovery goals (UCSRB 2007). There remains additional potential for improvement in habitat productivity in this population (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and improvement is needed to restore habitat to levels that will support a viable population.

2.7.2.4.4 Wenatchee River Subbasin

In the Wenatchee River subbasin, although less than 25 percent of the subbasin is privately owned, nearly two-thirds of the lineal area of anadromous streams, primarily lower gradient streams, is bordered by private lands. The Wenatchee River subbasin was also affected historically by mining, intensive livestock grazing, water diversions, timber harvest, and roadbuilding. These land uses have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many areas within the basin. However, some headwater areas are in relatively pristine condition and serve as strongholds for listed species. The primary habitat conditions in the Wenatchee River basin that currently limit abundance, productivity, spatial structure, and diversity of steelhead are a lack of habitat diversity and quantity, excessive sediment load, obstructions, a lack of channel stability, low flows, and high summer temperatures. Habitat diversity is affected by channel confinement, loss of floodplain connectivity and off-channel habitat, reduced quantities of large wood, and a lack of riparian vegetation. The mainstem, and many of its tributaries, also lack high-quality pools and spawning areas associated with pool tail-outs. The lack of pools in many areas is probably directly related to the loss of riparian vegetation, removal of large wood, and channel confinement (NMFS 2016d, UCRTT 2017).

Restoration actions in this subbasin have included actions to protect and restore stream flow, screen irrigation diversions, improve passage, improve stream channel complexity and floodplain connectivity, and protect and improve riparian areas (BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). Work has generally focused on several key areas of salmon and steelhead production, including Nason Creek, the White River, the Chiwawa River, the lower Wenatchee River, Mission Creek, Peshastin Creek, Chumstick Creek, and Icicle Creek. The actions have been targeted toward addressing limiting factors, and best available science indicates that they have improved and will continue to improve habitat function for the Wenatchee River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A).

The Wenatchee River population is currently at maintained status and must achieve at least viable status to meet ESA recovery goals (UCSRB 2007). There remains additional potential for improvement in habitat productivity in this population (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and improvement is needed to restore habitat to levels that will support a viable population.

2.7.2.4.5 Okanogan River Subbasin

In the Okanogan River subbasin, many factors, including beaver trapping, mining, grazing, and diversion of water for irrigation and other purposes, have contributed to habitat degradation. At present, barriers, poor water quality and low late-summer instream flows (mainstem and tributary) limit the survival, distribution, and productivity of steelhead. Summer water temperatures often exceed lethal tolerance levels for salmonids along the Okanogan River mainstem. These high temperatures are partially due to natural phenomena but are exacerbated by various anthropogenic activities, including dam operations, irrigation, and land management. Elevated water temperatures and low flows in summer and fall may limit adult run timing, as well as juvenile salmonid rearing in the mainstem and in several tributaries. Lack of stream flow and the presence of Conconully and Enloe Dams are barriers to fish passage, although there is debate whether anadromous salmonids historically passed the natural waterfalls that existed before construction of Enloe Dam (NMFS 2016d, UCRTT 2017). This population must achieve at least viable status under the ESA recovery plan (UCSRB 2007).

Restoration actions in this subbasin have included actions to protect and restore stream flow, screen irrigation diversions, improve passage, improve stream channel complexity and floodplain connectivity, and protect and improve riparian areas (BPA et al. 2013, 2016, 2020; BOR 2018, 2019b). These actions have been targeted at addressing limiting factors, and best available science indicates that they have improved and will continue to improve habitat function for the Okanogan River population, and that fish population abundance and productivity will respond positively. Benefits of some of these habitat improvement actions will continue to accrue over several decades (see Appendix A). Examples of improvement actions in the Okanogan subbasin include:

- In many years, low flows and obstructions blocked Loup Loup Creek, the southernmost tributary of the Okanogan River, making it impassable to fish trying to reach habitat in the creek's upper reaches. Agreements on water use, removal of culverts, and alteration of another barrier to improve fish passage reopened the creek in 2010. Increasing numbers of juvenile steelhead have been documented by annual snorkel surveys in the creek, and adult steelhead are also returning, with an average of 22 adult steelhead returning to the creek each year from 2012 to 2016 (OBMEP 2018).
- A multi-year restoration project on Omak Creek improved passage at a steep, boulder-choked falls, and PIT tagged adult steelhead were documented above the falls for the first time in the spring of 2014. This restoration action should contribute to an increased spawner capacity in future years in Omak Creek by increasing the amount of available stream length by approximately 81 percent (OBMEP 2015).

The Okanogan River population is currently at high risk and must achieve at least viable status to meet ESA recovery goals (UCSRB 2007). There remains additional potential for improvement in habitat productivity in this population (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and improvement is needed to restore habitat to levels that will support a viable population.

2.7.2.4.6 DPS Summary

While some degraded areas in the UCR steelhead DPS are likely on an improving trend as a result of past habitat improvement actions and improved land-use practices, in general, tributary habitat conditions are still degraded. These degraded habitat conditions continue to negatively affect the abundance, productivity, spatial structure, and diversity of the populations in this DPS, and present a major obstacle to achieving UCR steelhead recovery. In addition, ongoing development and land-use activities may continue to have negative effects. Three populations in the DPS are currently at high risk and the fourth (the Wenatchee River population) is at maintained status. All four populations must achieve at least viable status to achieve ESA recovery goals (UCSRB 2007). There remains additional potential for improvement in habitat productivity in all four populations (UCSRB 2007, NMFS 2016d, UCRTT 2017, ISAB 2018), and additional improvement is needed to restore habitat to levels that will support viable UCR steelhead populations.

2.7.2.5 Estuary Habitat

The Columbia River estuary provides important migratory habitat for UCR steelhead. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review (NMFS 2016d), have improved access and connectivity to floodplain habitat. From 2007 through 2019, the Action Agencies implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents a more than 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling steelhead (Johnson et al. 2018). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Floodplain habitat restoration can affect the performance of juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but the prey items produced in wetlands (primarily chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) are also exported to the mainstem, where they become available to salmon and steelhead migrating in these locations. Thus, while most yearling steelhead may not enter a tidal wetland channel, they derive benefits from wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry. Blood serum levels of IGF-1 for yearling steelhead collected in the estuary were higher than are typically found in hatchery fish before release, suggesting that prey quality and quantity in the estuary were sufficient for growth (PNNL and NMFS 2020). However, variation in IGF-1 levels was substantial (two to three times higher in some individuals than in others) (Beckman 2020), both within and between genetic stocks, indicating differences in feeding and migration patterns. Continuing to grow during estuary transit may be part of a strategy to escape predation during the ocean life stage through larger body size.

As discussed in Section 2.7.2.1 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as it receives contaminants from more than 100 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing the fact that contaminants are widespread throughout the estuarine food web (Fuhrer et al. 1996, Tetra Tech 1996, LCREP 2007). This includes the bodies of insects, which salmon in turn ingest. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.7.2.6 Predation

A variety of avian and fish predators consume juvenile UCR steelhead on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. This section discusses predation rates and describes management measures to reduce the effects of the growth of predator populations within the action area.

2.7.2.6.1 Avian Predation

Avian Predation in the Lower Columbia River Estuary

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and plume is about 40 percent of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including UCR steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island, where marine forage fish were available to diversify the terns' diet. Roby et al. (2017) estimated that terns on East Sand Island consumed an average of 5.1 million smolts per year, a 59 percent reduction from when the colony was on Rice Island.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this DPS were about 17.2 and 6.3 percent, respectively, before efforts to manage the size of these colonies (Evans and Payton 2020). Tern predation rates have decreased to 11.0 percent since 2007, a statistically credible difference (Appendix B). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on UCR steelhead was 6.3 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge[264] where smolts are likely to constitute a larger proportion of the diet. The average annual predation rates on UCR steelhead reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (5.8 during 2015 to 2017 and 0.7 percent in 2018) therefore cannot be

[264] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

directly compared to those before management began, and are likely to underestimate predation rates in the estuary.

Avian Predation in the Hydrosystem Reach

The following paragraphs describe avian predation in the mainstem Columbia River from the tailrace of Bonneville Dam to confluences of the Wenatchee, Entiat, Methow, and Okanogan Rivers.

UCR steelhead survival is affected in the mainstem by avian predators that forage at mainstem dams and in the reservoirs. The 2008 biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. Zorich et al. (2012) estimated that, compared to the number of smolts consumed at John Day Dam in 2009 and 2010, 84 to 94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[265]

Juvenile UCR steelhead migrating are also vulnerable to predation by terns nesting on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been focused on keeping terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015, and similar efforts by Reclamation are in progress at Goose Island. Predation rates on this DPS, which were 15.7 percent for terns on Goose Island, 4.1 percent on North Potholes Island, and 2.5 percent on Crescent Island before implementation of the IAPMP, were reduced to less than 0.1 percent at each site (Evans and Payton 2020) (Appendix B). However, the movement of terns to Blalock Islands in John Day Reservoir (Collis et al. 2019) increased predation rates on UCR steelhead from 0.5 percent to 4.5 percent (Evans and Payton 2020), reducing any net gain in the likelihood of survival.

Predation by gulls was not considered to warrant management actions at the time the IAPMP was developed, and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this DPS by gulls on Miller Rocks averaged 8.2

[265] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents, such as hazing from boats or other novel methods, continue to be deployed as necessary to minimize foraging by piscivorous water birds at the Corps' dams" (Zorich et al. 2012).

percent during 2007 to 2019 (Evans and Payton 2020) (Appendix B). Predation rates on UCR steelhead have averaged more than 2 percent per colony for gulls nesting on Island 20 (4.1 percent), Badger Island (5 percent), Crescent Island (5.8 percent), and the Blalock Islands (3.9 percent) in recent years (Evans and Payton 2020).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on UCR steelhead after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts over estimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different although related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns, but the ocean conditions that outmigrants experience, such as poor prey availability and the number and behavior of predators, which can trigger compensatory effects, also will be important.[266]

With respect to management of terns in the estuary, Caspian terns nesting on East Sand Island were eating an annual average of 17.2 percent of the juvenile UCR steelhead outmigrants per

[266] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

year before management actions reduced the size of that colony and 11.0 percent per year thereafter (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (17.2 percent) and the average 6.2 percent per year decrease achieved by reducing the size of the tern colony, it is likely that this management measure led to increased adult returns for UCR steelhead, before the downturn in ocean condition overwhelmed improvements in freshwater survival. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 6.3 percent to less than 1 percent. However, in this case, smolt predation rates are likely to have increased because thousands of birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[267]

2.7.2.6.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia and Snake Rivers followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). From 2015 to 2019, an annual average of 42 adult and 198 juvenile steelhead per year were incidentally caught in the Sport Reward Fishery (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to DPS, we assume that some were UCR steelhead.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year from 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). They did not report killing or handling any adult or juvenile steelhead during the 5-year period. In addition, they caught, but did not remove, an annual average of 967 smallmouth bass and 379 walleye at the two dam angling sites combined over the last 5 years (Williams et al. 2015, 2016, 2017, 2018; Winther et

[267] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

al. 2019). The Oregon and Washington Departments of Fish and Wildlife, which manage these two non-native predator species, are currently discussing the possibility of removing smallmouth bass and walleye from the system when captured by the Dam Angling Program (as with pikeminnow). Both agencies have already removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these species, in addition to pikeminnow, both in the lower Columbia River and the CRS reservoirs (i.e., hydrosystem reach), would incrementally improve juvenile salmonid survival during their migration to the ocean.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile steelhead, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. Williams et al. (2018) found a lower than average abundance (1990 to 2018) for northern pikeminnow in The Dalles and John Day Reservoirs along with a two to three times higher than average abundance for smallmouth bass and walleye in the same reservoirs. With the exception of the John Day forebay area, smallmouth bass abundance index values calculated for 2018 were the highest observed since 1990. Abundance index values provide a means to characterize relative predation impacts (Williams et al. 2018). Similarly, in 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP, as well as a substantial increase in their predatory impact in the lower Snake reservoirs since program design and implementation. Also compared to previous years, walleye were relatively abundant in both The Dalles and John Day Reservoirs during 2018 spring sampling, but few were encountered during the summer sampling. The greatest walleye abundance indices were observed in the John Day Dam tailrace and mid-reservoir, with the tailrace value being the highest recorded abundance to date (Williams et al. 2018). These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal still remains unclear. The complexity of inter-species interactions, combined with inter-reservoir variability and environmental variability, make this a difficult research question to answer without a more intensive sampling and evaluation program (Williams et al. 2018, Winther et al. 2019). However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the

Columbia River and the ocean, we do not expect that all of the steelhead that are “saved” from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including UCR steelhead. As such, it likely continues to benefit the DPS.

2.7.2.6.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions, Steller sea lions, and harbor seals consume adult salmonids from the mouth of the Columbia River and tributaries up to the tailrace of Bonneville Dam. A small number of California sea lions have also been observed in Bonneville Reservoir but have been absent in recent years. ODFW counted the number of individual California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, from 1997 through 2017. Adult UCR steelhead are migrating through the lower river during July to September. Although there has been no clear trend in peak monthly counts of California sea lions at the East Mooring Basin during July and August in recent years, numbers increased from less than 500 in September 2008 to 2014 to more than 1,000 in September 2015 to 2016 (Wright 2018). Estimates of steelhead predation by pinnipeds in the lower Columbia River estuary (i.e., downstream of the Bonneville tailrace) are not available for the summer time period, when UCR steelhead are present. Instead, monitoring efforts have focused on California sea lion predation on SR spring/summer Chinook salmon during January to May (Rub et al. 2019).

Adult UCR steelhead are vulnerable to pinniped predation throughout the lower Columbia River. Through an authorization under the MMPA, agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 to 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019 respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the mainstem of the Columbia River between river mile 112 and McNary Dam (river mile 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

Counts of individual pinnipeds observed in the Bonneville tailrace have generally increased from 2002 until they peaked in 2015. Beginning in 2016, spring pinniped abundance at Bonneville Dam has consistently decreased with the second lowest number of pinnipeds counted in 2019 (Tidwell et al. 2020). While spring pinniped counts have declined in recent years, counts of individual Steller sea lions have been increasing in the last decade during the late summer and fall period when UCR steelhead are migrating. Between July 21 and December 31, 2017, Tidwell et al. (2018) documented an average of 14.5 Steller sea lions and 47 individually identifiable Steller sea lions in the tailrace of Bonneville Dam. A small number (zero to five) of California sea lions have also been observed in Bonneville Reservoir in recent years.

Due to the repeated entry of sea lions into the adult ladders at Bonneville Dam, the Corps began constructing physical exclusion devices in 2006 to block pinnipeds but allow fish passage. These sea lion exclusion devices are installed at all ladder entrances at Bonneville Dam when UCR steelhead are present (Tidwell et al. 2020). In addition, the Corps has installed smaller physical exclusion gratings on the 16 FOGs along the face of Powerhouse 2 that allow fish to enter the collection channel and pass via the Washington shore ladder. The sea lion exclusion devices and FOGs successfully prevent pinnipeds from entering the adult fish ladders of Bonneville Dam, and thus further minimize opportunities to prey on UCR steelhead.

Adjusted consumption estimates for all steelhead at Bonneville Dam by pinnipeds is 1.6 percent (Tidwell et al. 2020). Based on the timing of the observations in the study, that number is a reasonable estimate for UCR steelhead.

2.7.2.7 Research, Monitoring, and Evaluation Activities

The primary effects of past and present CRS-related RME programs on UCR steelhead are associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were UCR steelhead. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the UCR steelhead DPS by reducing predation throughout a large portion of the migration corridor.

For all other CRS-related RME programs, we estimated the number of UCR steelhead that have been handled (or have died) each year as the average annual take reported for 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of UCR steelhead associated with the Smolt Monitoring Program and the CSS were as follows:
    - Zero hatchery and zero natural-origin adults were handled.
    - Zero hatchery and zero natural-origin adults died.
    - 1,905 hatchery and 239 natural-origin juveniles were handled.
    - Four hatchery and zero natural-origin juveniles died.

- Average annual estimates for UCR steelhead handling and mortality for all other fish RME programs were as follows:
  - 19 hatchery and 31natural-origin adults were handled.
  - Zero hatchery and zero natural-origin adults died.
  - 4,140 hatchery and 6,132 natural-origin juveniles were handled.
  - Seven hatchery and 35 natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) of UCR steelhead associated with these elements of the RME program has, on average, affected less than 1 percent of the natural-origin adult (recent, 5-year average) run (arriving at Priest Rapids Dam) and 3.0 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects UCR steelhead.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the DPS level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.7.2.8 Critical Habitat

The condition of UCR steelhead critical habitat in the action area without the consequences caused by the proposed action is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized in Table 2.7-8, below. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use and water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for steelhead production have been weakened. Conditions in the hydrosystem reach were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for UCR steelhead have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.7-8. Physical and biological features (PBFs) of designated critical habitat for UCR steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater spawning sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for all populations. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning sites for all populations. Diminished stream flow (water withdrawals, drought) has reduced the quantity and quality of freshwater spawning sites for all populations. Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced the quality of freshwater spawning sites for all populations. Many tributary habitat improvement actions implemented in the upper Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to freshwater spawning sites.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, natural cover.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater rearing sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced the quality of freshwater rearing sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Excessive sediment in streambeds (forest and agricultural practices) has reduced the quality of freshwater rearing sites for all populations. Many tributary habitat improvement actions implemented in the Upper Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to freshwater rearing sites.
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity and natural cover.	*Effects in the migration corridors apply to all populations of UCR steelhead:* Alteration of the seasonal flow regime in the Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderately negative effect in lower flow years. Alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in late summer and fall (hydrosystem development and operations).[1] Cooler spring temperatures do not affect the functioning of the mainstem as a migration corridor for juvenile UCR steelhead. However, adults enter the lower Columbia River during summer so that this alteration adversely affects the functioning of the migration corridor for adults. Reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume (hydrosystem development), may have reduced "natural cover" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining). The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable lubricants" where feasible.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Delay and mortality of some juveniles and adults at up to five PUD-owned and four CRS dams on the mainstem Columbia River has increased obstructions in the migration corridor. Increased exposure of juveniles to TDG in the lower Snake and Columbia Rivers and at least 35 miles below Bonneville Dam during involuntary[2] and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor for juvenile steelhead. The incidence of adverse effects (GBT in juveniles and adults) appears to have been small (1 to 2 percent) in recent years with TDG up to 120 percent. The operation of the hydrosystem has increased obstructions by creating conditions that delay and injure/kill some juveniles and a smaller proportion of adults in the migration corridor. However, the functioning of the migration corridor has increased substantially for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult steelhead during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past the dams or overwintering within the fish facilities or turbine units). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile steelhead because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems). Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for avian and fish predators in the tailraces of mainstem dams. Avian

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, propane cannons, and limited amounts of lethal take. Fish predation is addressed by dam angling at several dams. Delays of adults at the ladder entrances at Bonneville Dam has increased the risk of pinniped predation (excessive predation related to hydrosystem development and operation) in the migration corridor. Pinniped predation is addressed by the use of sea lion excluder devices at the fishway entrances at Bonneville Dam.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity and salinity, natural cover, juvenile and adult forage.	*Effects in estuarine areas apply to all populations of UCR steelhead:* Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling steelhead by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the Caspian Tern Management Plan on East Sand Island is reducing excessive predation in the migration corridor for UCR steelhead, but depending on ocean conditions and compensatory effects, may not be increasing adult returns. Implementation of the Double-crested Cormorant Management Plan may have contributed to the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island.
Nearshore marine areas[3]	Free of obstruction and excessive predation with water quality, quantity and forage.	Concerns about increased pinniped predation and adequate forage.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Spill is characterized as “involuntary” when water is spilled over a dam’s spillway because it cannot be stored in a reservoir behind the dam or passed through turbines to generate electricity, such as during maintenance activities, periods of low energy demand, or periods of high river flow. Involuntary spill is most common in the spring.

[3] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Habitat quality in tributary streams in the upper Columbia portion of the Interior Columbia Recovery Domain varies from good in higher elevation stream reaches to degraded in lower elevation reaches, especially near valley bottoms. These areas are subject to heavy agricultural and urban development. Human activities that have contributed to these factors include dams, water diversions, stream channelization and diking, roads and railways, timber harvest, grazing, and urban and rural development (UCSRB 2015). Natural disturbances that have had a large effect on habitat include wildfires, with subsequent effects on runoff and sedimentation in areas used for spawning and rearing.

Many tributary stream reaches designated as critical habitat are listed on Oregon and Washington's Clean Water Act Section 303(d) lists for water temperature. Areas that were historically suitable spawning and rearing habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, withdrawal of water for agricultural or municipal use, and periodic droughts have all contributed to elevated stream temperatures. Furthermore, contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016d). They can negatively impact critical habitat and the organisms associated with these areas.

The general effects of mainstem and tributary dams on the functioning of critical habitat for UCR steelhead are:

- Lost access to historical spawning areas behind dams built without fish passage facilities (obstructions).
- Altered juvenile and adult passage survival at dams with passage facilities (obstructions).
- Altered flows and seasonal timing (reduced water quantity).
- Altered seasonal temperatures and elevated dissolved gas (reduced water quality).
- Reduced sediment transport and turbidity (reduced water quality).
- Altered food webs, including both predators and prey (reduced prey production and increased numbers of predators, including non-natives).

Habitat quality of migratory corridors in this area was substantially affected by the development and operation of the CRS dams and reservoirs in the mainstem lower Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the upper Columbia River basin. Hydrosystem development modified natural flow regimes, resulting in warmer late summer/fall water temperatures. Changes in fish communities led to increased rates of piscivorous predation on juvenile salmon and steelhead. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines and juvenile bypass systems, have also killed outmigrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented measures in the juvenile and adult migration corridors including 24-hour volitional spill, surface passage routes, upgrades to juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

In addition, basinwide water management activities, including the operation of the CRS water storage projects for flood control, power generation, and water withdrawals have substantially reduced average monthly flows at Bonneville Dam during May to July and increased them during October to March compared to an unregulated system. Reduced spring flows, combined with the existence of mainstem dams, increased travel times during the juvenile outmigration period for UCR steelhead, increasing the risk of predation. Since salmon and steelhead were listed and critical habitat was designated under the ESA, the Action Agencies have made substantial changes to minimize these operational effects by limiting storage reservoir elevations to minimums needed for flood risk management and passing more water during the spring refill period. By taking these actions, the Action Agencies have increased flows in the spring and summer, which helps replicate the natural hydrograph. As a result, the functioning of the migration corridor has been improved by reduced exposure to predators, increased turbidity (which can provide visual cover), and increased access to cover and prey in nearshore mainstem habitat.

The functioning of juvenile rearing and migration habitat for UCR steelhead in the lower Columbia River estuary has been reduced by the conversion of more than 70 percent of the original marshes and spruce swamps to industrial, transportation, recreational, agricultural, or urban uses. Water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. Reduced sediment delivery to the lower river and estuary, combined with in-water structures that focus flow in the navigation channel and bank armoring, have altered the development of habitat along the margins of the river. All of these changes have reduced the availability of prey for smolts between Bonneville Dam and ocean entry.

In the hydrosystem reach, altered habitats in project reservoirs and tailraces create more favorable habitat conditions for fish predators; the latter include native northern pikeminnow and non-native walleye and smallmouth bass. The effects of the non-native species and those of pikeminnow, to the extent they are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the juvenile migration corridor. Similarly, sea-lion predation on adult UCR steelhead in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary is a natural phenomenon and is not excessive predation in the context of an effect on the functioning of critical habitat.

Restoration activities in tributary spawning and rearing areas and in the estuary that are addressing habitat quality and complexity, and improved functioning of the juvenile migration corridor (e.g., 24-hour and flexible spill, new surface passage structures, and improved spillway designs) have improved the baseline condition for some components of the PBFs. However, more restoration is needed before the PBFs can fully support the conservation of UCR steelhead.

2.7.2.9 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. NMFS' most recent 5-year review evaluated new information regarding the status and trends of UCR steelhead, including recent biological opinions issued for actions likely to affect the UCR steelhead DPS and key emergent or ongoing habitat concerns (NMFS 2016d). From January 2015 through May 22, 2020, we completed 426 formal consultations that addressed effects to UCR steelhead.[268] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species) such as the Mitchell Act consultation, and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat and riparian condition and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

[268] PCTS data query July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.7.2.10 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of UCR steelhead populations. Recent improvements in passage conditions at mainstem FERC licensed and CRS dams, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, tributary habitat improvements, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. The recovery plan identified habitat degradation, hydropower systems, harvest, hatcheries, and changes in estuarine habitat, climate change, inadequacy of regulatory mechanisms, fluctuating ocean cycles, and predation as limiting factors that continue to negatively affect UCR steelhead populations (UCSRB 2007).

Likewise, the environmental baseline area does not fully support the conservation value of designated critical habitat for UCR steelhead, as described above. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of some of these PBFs of critical habitat. For example, surface passage structures and spill operations have improved safe passage for juvenile UCR steelhead at CRS dams in the lower Columbia River. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. Similarly, projects that have protected or restored tributary habitat used by this DPS have improved the functioning of the freshwater spawning and rearing sites. However, the factors described above continue to have negative effects on these PBFs.

2.7.3 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.7.3.1 Effects to Species

2.7.3.1.1 Spill and Seasonal Flow Operations

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams. The intent of flexible spill operations is to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem.[269] Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG spill ("gas cap spill") for a minimum of 16 hours per day, and under lower spill levels ("performance standard spill") for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill at all hours. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs maximum spill constraint) for 16 hours per day with 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan, unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in performance standard spill periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated

[269] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.7-9.

Table 2.7-9. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.7-10. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.7-10. Proposed summer spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[2]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March; decreased flows from May through August, and little change in flows in April and September) described in the Environmental Baseline section will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in all project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce high TDG events associated with spill in the winter, which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. The proportional effect on flow is higher in the lower Snake River than in the lower Columbia River due to its smaller flow volume. Nonetheless these flow changes do transfer into the lower Columbia River and have the potential to affect UCR steelhead in the lower Columbia River. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.7-6).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

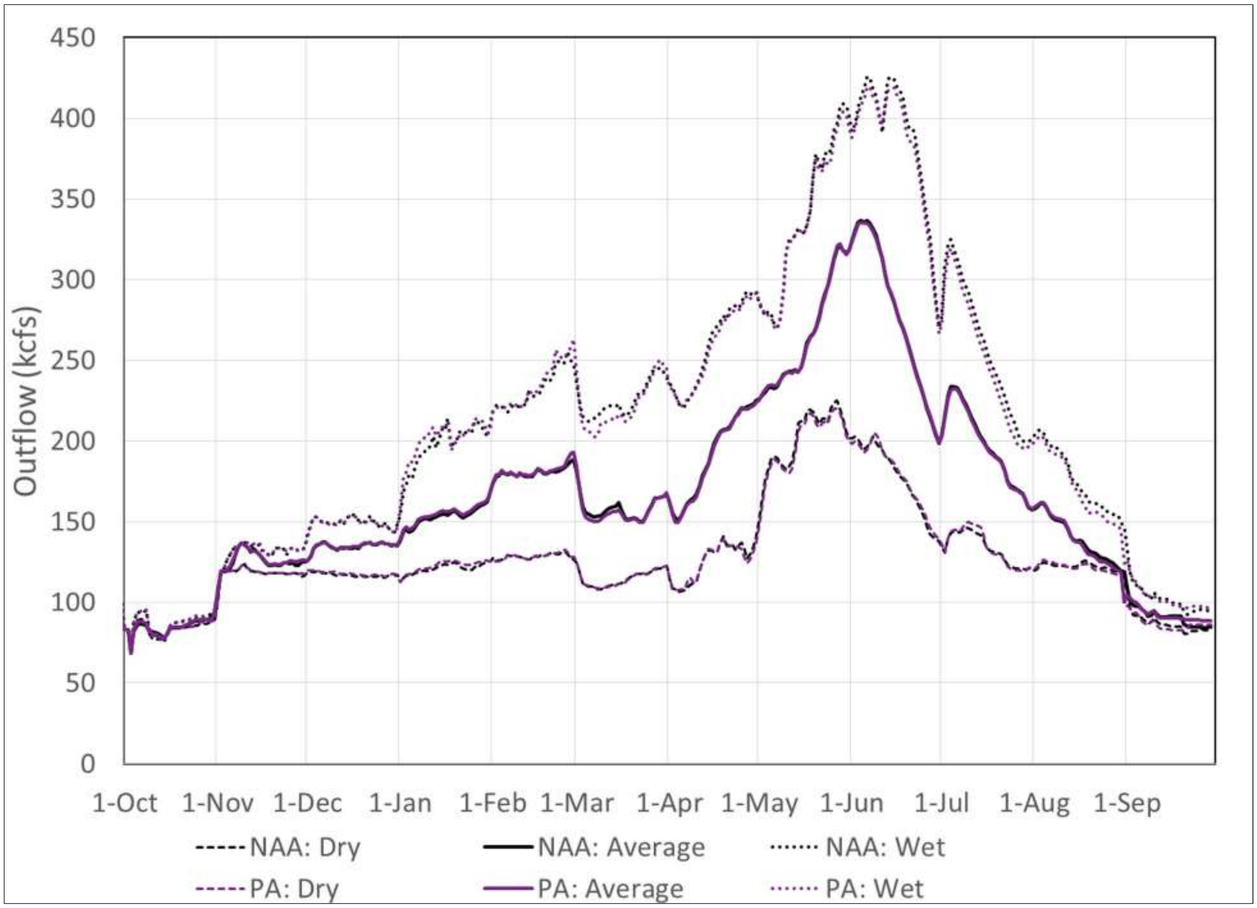

Figure 2.7-6. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

Juvenile UCR steelhead migrate through the lower Columbia River primarily in April to early-June , and the Action Agencies will operate to meet seasonal flow objectives to support juvenile migrants during that period. Adult UCR steelhead migrate primarily in July to early-September. The proposed change in flow would be too small to affect river temperature during the adult migration period, which would be the attribute of highest concern. The associated effects on UCR steelhead smolts or adults should not change from recent conditions by a meaningful amount.

The effects of the proposed hydrosystem operations and the non-operational measures on UCR steelhead salmon and its habitat are described below.

2.7.3.1.2 Water Quality

The operation of the CRS will continue to affect water quality parameters in the mainstem migration corridor. This includes delayed spring warming, delayed fall cooling, and reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs.

Taken together, the proposed measures at Grand Coulee Dam would influence reservoir elevations at Lake Roosevelt; however, effects on water temperature would be negligible. At Chief Joseph Dam, monthly outflows are predicted to be similar to or about 1 percent less for all types of water years, and tailrace temperatures are expected to be similar to existing conditions. Tailrace temperatures should not be measurably altered by the proposed action and are predicted to continue to exceed the Washington State water quality standard for August and September (7-day average of the daily maximum temperature of 63.5°F). There will be little difference in temperature between Grand Coulee Dam and Chief Joseph Dam, showing that water temperatures below Lake Roosevelt are unchanged through Rufus Woods Lake.

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacity spill. These events will continue to occur most frequently in May and June but may also occur in other months.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). For UCR steelhead smolts, the proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of McNary Dam to at least 35 miles downstream of Bonneville Dam. Individuals from all "upstream" populations would be exposed to a greater extent than those from "downstream" populations. Smolts typically migrate at depths that effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020). Evidence suggests depth protects *Oncorhynchus mykiss* from GBT by approximately 10 percent TDG supersaturation per meter depth, and there is evidence for depth compensation behavior by fish in TDG supersaturated water which may alleviate GBT (Pleizier et al. 2020). However, steelhead smolts are known to migrate nearer the surface than other species, meaning they should be more exposed to higher TDG levels than other species. Data from all fish sampled in the CRS Gas Bubble Trauma Monitoring Program (1996 to 2019) indicate that signs of GBT were almost non-existent below 120 percent TDG, increased slightly between 121 and 125 percent TDG, and then increased in both incidence and severity when TDG levels exceeded 125 percent (FPC 2019). The available information in Zabel (2019) and Widener et al. (2020) suggests that the relatively high TDG exposure often exceeding 125 percent during high flow years (e.g., 2006 and 2011) did not reduce smolt survival through the CRS. Thus, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable based on reach survival studies) increase in mortality of juvenile UCR steelhead.

The majority of adult UCR steelhead migrate after the spring spill period and will not be affected by the proposed flexible spring spill operation. Less than 1 percent of the DPS holds up in the larger rivers over the winter and then continues upstream through the dams in the spring (Keefer et al. 2016). Thus, only a very small portion of the DPS—those holding overwinter and continuing their migration the following year—could be exposed to the increased spill associated with the flexible spring spill operation. Adults also migrate at depths that reduce the effective exposure to TDG through depth compensation mechanisms. Thus, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality for adults that are exposed.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[270] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (EPA 2018, Perhar and Arhonditsis 2014). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for

[270] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

juvenile and adult migrants. Any effects of oil and grease on UCR steelhead are likely to be very small and are not expected to detectably affect reach survival estimates.

Sediment Transport

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency especially during the spring freshet. The increased water transparency hypothetically increases the exposure of UCR steelhead juveniles to predators (Gregory 1993, Gregory and Levings 1998, Sontag 2013) and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile UCR steelhead spend only days to weeks in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

2.7.3.1.3 Project Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems (BPA et al. 2020). Maintenance activities evaluated and covered under this opinion can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance, as summarized in Section 1.3 of this opinion and in further detail in BPA et al. (2020).

Fishway structures (e.g., fish ladders, screens, bypass systems) will be routinely maintained and temporarily removed from service on a scheduled basis during the established in-water work period (December to March), in accordance with the Fish Passage Plan and coordinated through FPOM to minimize impacts to adult and juvenile migrants. At Bonneville Dam, routine dredging in the forebay and rock removal in the spillway will occur every year or two to ensure reliable operation and structural integrity of the fishways. Turbine unit maintenance is planned at all dams and will be coordinated through FPOM to minimize and avoid delay, injury, and mortality.

Routine outages of fishways are necessary to maintain reliability, but these temporary outages can cause delay and mortality for adult and juvenile migrants that attempt to migrate at the time of the outage. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of, UCR steelhead that are migrating, and these effects will occur at extremely low levels similar to what was observed in the recent past. Passage delay and conversion rates will be monitored and maintenance schedules may be modified through FPOM or adaptive management if evidence indicates elevated delay and mortality are occurring.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization and major rehabilitations. Non-routine maintenance expected in the timeframe of the proposed action includes turbine replacement at McNary Dam which is expected to begin within the next 15 years. At John Day Dam, turbine replacement may begin, but it is uncertain at this time if it will be completed, within the 15-year period of the proposed action. The proposed maintenance at Grand Coulee could result in outages and additional spill in limited situations, but changes to total outflows are not expected. Non-routine maintenance (related to turbines or spillbays) expected in the proposed action can increase TDG during uncontrolled spill by temporarily reducing powerhouse capacity and may cause suboptimal tailrace conditions which can delay passage. The installation of improved fish passage turbines will likely improve turbine survival and reliability once completed. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce risk to adults and juveniles.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated with NMFS and through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize negative effects on fish. Fish passage metrics will be monitored with counts and PIT tags to ensure unscheduled maintenance activities do not result in negative impacts to the ESU.

Overall, scheduled maintenance activities are expected to continue to negatively affect small numbers of adult UCR steelhead annually. A few adults will be delayed or die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. Very few juveniles will likely be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult UCR steelhead will likely continue to result in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes will continue to minimize the impacts.

2.7.3.1.4 Adult Migration/Survival

Adult survival rates for UCR steelhead are expected to continue to average about 92.0 percent (2009 to 2018 average) from Bonneville to McNary Dam under the proposed action. The great majority of UCR steelhead migrate after the flexible spring spill operation has ended. For those few adults that overwinter in the lower Columbia River and continue migrating upstream the following spring, tailrace conditions at John Day Dam during low to moderate flows could be degraded by the increased spill levels (16 hours per day) resulting from the flexible spring spill operation during the spring spill period. While this operation could negatively affect passage conditions for migrating adults (i.e., the ability to find fishway entrances), 8 hours of performance level spill should be sufficient to prevent any measurable impacts to passage or adult survival. The flexible spill operations should not negatively affect passage conditions for UCR steelhead at the other lower Columbia River dams. Keefer et al. (2016) estimated that mean annual fallback rates were about 6 to 9 percent at the lower Columbia River dams. UCR steelhead would likely fallback at lower rates as they tend to migrate more directly to their natal streams than do SR steelhead. Fallback rates, which are associated at many dams with higher spill levels, will likely increase slightly at the lower Columbia River dams (except The Dalles), but this effect will be small because of the scarcity of adults present. Adult fallback has been associated with longer migration times and reduced survival rates. However, the additional fallback would most likely happen through a spillbay (rather than a turbine unit or screened bypass system), which would be expected to increase the survival of these fish, relative to the other passage routes (Colotello et al. 2013, Normandeau et al. 2014). This would potentially offset some of the potential impact of increased fallback rates associated with increased spill levels under the proposed action. In addition, adaptive management processes can be used to identify (daily or weekly estimates of fallback-reascension rates) and remedy (through in-season management processes) excessive fallback or migration delays, if it occurs, as was done for adult delays at Little Goose Dam in recent years.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. This change will affect adult UCR steelhead that may be migrating after that date in August by improving adult ladder attraction conditions and reducing fallback. However, individuals that fell back would experience greater risk because they would be more likely to pass via turbines and juvenile bypass systems instead of the spillway. A substantial portion of UCR steelhead will be migrating when this occurs. While spill will be reduced during this period compared to baseline, a spillway route will be provided for fish that intend to fall back. The available information on steelhead fallback indicates that adult steelhead prefer to use spillway routes over turbine routes if made available, and the reduced amount of spill provided in late August will still be sufficient for effective attraction and passage survival (Ham et al. 2012). Based on the correlation between spill and fallback rates, the overall operation will likely lead to a minor reduction in project fallback rates, with the possibility of a very small increase in turbine passage. This will likely result in a small positive effect for adults or no net measurable change in survival. Available data, including PIT detections, fallback rates, conversion rates, and adult counts, will be actively monitored for adaptive management.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14. The increase in operation range is expected to slightly reduce the average flow rate in the reservoirs, but the flow change is minimal and is not expected to affect adult survival rates of UCR steelhead since it will occur outside of their migration corridor, and only a few strays might experience this flow condition.

The Action Agencies propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP (262.5 to 264.5 feet), except during the spring spill period, when the John Day forebay operating elevation window will be increased. From April 10 to June 1–15, John Day Reservoir elevation will be held between 264.5 feet and 266.5 feet to deter piscivorous Caspian terns from nesting in the Blalock Islands Complex (see Section 2.2.3.1.10). Following this operation, John Day Reservoir elevation would return to MIP +2 feet operation through August 31. The increase in operating range is expected to slightly reduce velocities in John Day Reservoir, but the velocity change is not expected to affect adult migration timing or survival rates.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. PIT-tag data indicate that very few adult UCR steelhead will migrate through the Snake River during this operation, so we expect there will be no or extremely minimal effect on adult migration timing or survival for this DPS.

The proposed operations at Libby Dam, Hungry Horse Dam, and Grand Coulee Dam should not measurably affect adult migration or survival because the flow alterations in the Columbia River are relatively small (less than 2 kcfs measured at Bonneville Dam; see discussion above) during the months when these fish migrate. The small reduction of flow would not be sufficient to affect river temperature, which would be the most relevant effect influencing adult migration success. The proposed operation at Dworshak Dam should not affect adults because any potential flow reduction would only occur in high flow years and thus not add risk to migrating adults.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action should only occur during higher flows in the spring and should not affect adult UCR steelhead that primarily migrate in the summer and fall. Kelts and early migrating or overwintering adult steelhead could potentially be exposed to these operations if they were to fall back through a unit when these operations are occurring, but these instances should be very rare and any negative effects should be extremely minimal.

2.7.3.1.5 Juvenile Migration/Survival

The Action Agencies propose to continue to provide fish passage spill (conventional and surface passage), operate juvenile bypass system, and perform other operations (e.g., ice and trash sluiceways, Bonneville corner collector, etc.) for juvenile passage at the four lower Columbia River dams. Surface passage structures exist at all four lower Columbia River dams, and three of them have juvenile bypass systems. The Dalles Dam does not have a juvenile bypass system because of low powerhouse passage rates. Increased spill levels resulting from the flexible spring spill operation are expected to have little effect on tailrace conditions at Bonneville or McNary Dams, but will likely cause eddies to form at John Day Dam under low flow conditions. The latter would be likely to reduce the survival of juvenile steelhead passing through the spillway by a potentially small, but unknown amount. Increased spill levels at three of the four lower Columbia River mainstem dams (The Dalles Dam operation will continue spilling at 40 percent) would generally be expected to slightly increase direct dam passage survival rates of inriver migrating smolts as spillway survival rates generally exceed those in the juvenile bypass systems or through the turbine units. Increases in downstream migration survival are expected to increase population productivity by delivering more smolts to the ocean, resulting in more adults returning. Overall, the survival of inriver migrating juvenile UCR steelhead from all populations and MPGs should increase slightly as a result of implementing the flexible spring spill levels at each of the four mainstem dams. Increases in downstream migration survival are expected to increase population productivity by delivering more smolts to the ocean, resulting in more adults returning.

NMFS' COMPASS model predicts that inriver survival rates of UCR steelhead juveniles will not change substantially as a result of increased spring spill levels associated with the flexible spill operation compared to the No Action Alternative (USACE et al. 2020). The CSS model predicts more substantial increases in juvenile survival, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillbays) will increase adult returns of the Snake River populations by about 28 percent. If this is the case, to the extent that UCR steelhead experience latent mortality associated with dams, higher spill levels would be expected to increase adult returns accordingly, but likely less than half (14 percent) that hypothesized by the CSS for SRB steelhead (28 percent), because they pass through up to half as many Federal projects (Yakima River MPG), and spill at some projects is unchanged (e.g., The Dalles Dam).

The proposed operations at Libby Dam, Hungry Horse Dam, Grand Coulee Dam, and Dworshak Dam will alter flows by less than two percent during the spring migration period. This would be expected to result in very small increases in travel times in April and May, and small decreases in travel times in June, but should not measurably affect juvenile survival. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

The Action Agencies propose to reduce summer spill at the four mainstem dams from August 15 to 31. Because UCR steelhead juveniles migrate during the spring, they will not be affected by a reduction in summer spill in late August.

The Action Agencies propose a change in pool elevation in John Day Reservoir starting April 10 and ending sometime between June 1 and June 15 to reduce predation associated with the Blalocks Island tern colony (see discussion below). Increasing the elevation of John Day Reservoir is likely to increase downstream travel time for juveniles because an increase in surface area with a given river flow will slow down the water and the fish migrating through it. However, the net effect of the John Day Reservoir and flexible spill operations, based on COMPASS modeling for UCR steelhead (see Section 2.7.3.1.5), is likely to have no substantive effect on juvenile travel times for UCR juvenile steelhead migrating through this reach.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14. The increase in operating range will not affect UCR steelhead juveniles migrating in the Columbia River.

Power generation at Snake River projects may cease for short periods between October 15 and February 28 and will result in no flow past the projects in the Snake River during these periods. Because they are not present in the Snake River, no UCR steelhead juveniles migrating in the Columbia River will be measurably impacted by this operation.

As described above (see Section 2.7.3.1.4, Adult Migration/Survival), under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, but the number of juveniles affected should be extremely low because of the limited time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure, would slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, and would slightly increase powerhouse passage rates of UCR steelhead juveniles. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units and increase powerhouse passage rates.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project at the lower Columbia River dams. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation and, thus, likely overestimates the duration that would actually be implemented. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of UCR steelhead juveniles between McNary and Bonneville Dams, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurable reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

COMPASS Model Results

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT tags (detection efficiencies and project and reach survival estimates) and acoustic tags (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model.

For UCR steelhead, COMPASS estimates that the increased spill levels at the lower Columbia River dams resulting from the proposed action (flexible spill up to 125 percent TDG) and increased pool elevation at John Day Dam:

- Average travel times from McNary tailrace to Bonneville tailrace of 6.5 days.
- Average juvenile survival from McNary tailrace to Bonneville tailrace of 66.2 percent.
- Average juvenile survival from Rock Island tailrace to Bonneville tailrace, a reach that includes McNary pool, of 48.2 percent.
- Average number of spill passage events (the inverse of the CSS's PITPH metric) of 4.42 for the seven dams traversed from Rock Island Dam to Bonneville Dam.

The draft EIS used COMPASS to compare the Preferred Alternative (proposed action) to the No Action Alternative (2016 Operations) (USACE et al. 2020). The median model results (USACE et al. 2020, Tables 7 to 23) indicated that the flexible spring spill operations (proposed action), compared to the No Action Alternative, would:

- Have no substantive effect on juvenile travel times from McNary to Bonneville Dam (zero days).
- Have no substantive effect on juvenile survival from McNary to Bonneville Dam (minus 0.1 percent).
- Slightly increase the number of spillway passage events from Rock Island to Bonneville Dam by about 0.14.

These results support our qualitative expectations that juvenile survival rates for UCR steelhead in the lower Columbia River would not change in biologically significant ways (i.e., enough to substantially affect the abundance or productivity of any UCR steelhead population) as a result of the proposed operation. Though it has not been explicitly applied to UCR steelhead, the CSS hypothesizes that flexible spring spill would reduce latent mortality by reducing the number of powerhouse encounters. If this proves to be true, an additional small increase in adult returns is possible. However, another possible explanation for reduced return probabilities of bypassed fish is that smaller fish and those in poorer condition tend to enter bypass systems with higher probability (Zabel et al. 2005, ISAB 2012, Hostetter et al. 2015, Faulkner et al. 2019), and smaller fish and fish in poorer condition also have lower return probability (Ward and Slaney 1988, Zabel and Williams 2002, Evans et al. 2014). This suggests that the apparent effects of juvenile bypasses on juvenile survival and adult return probability are due, at least in part, to the correlation between bypass probability and fish size and condition, and not due to bypass passage itself. Thus, increasing spill levels will incrementally increase the proportion of spillway passed fish and reduce travel times and could, assuming spillway passage survival rates are not substantially reduced as a result of poor egress and tailrace conditions, slightly improve direct juvenile survival rates. But increasing spill levels might not increase adult returns to the extent hypothesized by the CSS. It is also important to note that since higher spill levels result in unbalanced flows between the powerhouse and spillways, which can result in degraded tailrace conditions (eddies, etc.), juvenile survival could be lower than COMPASS predicts as a result of extended tailrace delay and the potential for increased predation or increased exposure to high TDG levels at some projects.

2.7.3.1.6 Transportation

Consistent with current practices, no UCR steelhead smolts will be transported as a result of the proposed action. Any changes to transportation operations in 2020 would not affect UCR steelhead because juveniles only migrate downstream of the lower Snake River collector projects.

2.7.3.1.7 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to UCR steelhead as they migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty about predicting the availability of habitat restoration actions into the future and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their estuary habitat monitoring program, the component of the CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and be initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the action effectiveness monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program either will confirm that these floodplain reconnections are enhancing conditions for salmonids such as UCR steelhead as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change considerations and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management, which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the influx of insect and amphipod prey to the mainstem migration corridor for juvenile UCR steelhead. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[271] of all UCR steelhead populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

[271] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile steelhead opportunities to move into wetland habitats for food and refuge from predators. Moreover the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the UCR steelhead DPS.

2.7.3.1.8 Tributary Habitat

For the UCR steelhead DPS, the Action Agencies will implement tributary habitat improvements to achieve the metrics outlined in Table 2.7-11 for the single MPG in the DPS. Actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations, and will accomplish the specific metrics identified for the single MPG (BPA et al. 2020).

Table 2.7-11. Proposed tributary habitat metrics (2021–2036) for the single major population group in the UCR steelhead DPS.

Upper Columbia River Steelhead DPS Major Population Group[1]	Metrics					
	Flow Protected (cfs)	Flow Enhanced (acre-feet)	Entrainment Screening (# screens)	Habitat Access (miles)	Stream Complexity (miles)	Riparian Habitat Improved (acres)
East Slope Cascades	42	8254	10	35	9	109

[1] The habitat actions that produce these metrics will be completed or in process by the end of 2036.

To develop these metrics, the Action Agencies reviewed implementation under the 2008 and 2019 biological opinions and developed metrics assuming a consistent level of effort for tributary habitat implementation. In addition, the Action Agencies have committed to continuing to improve the strategic implementation of the program, to implement the program with input from the THSC that was convened under the 2019 biological opinion, to convene a TTT to provide input to program implementation, to report on implementation using metrics that will allow NMFS to evaluate implementation of the program, to undertake comprehensive program reviews every 5 years to evaluate how to enhance benefits from the program, and to conduct RME to assess tributary habitat conditions, limiting factors, and action effectiveness, and to inform our understanding of critical uncertainties (BPA et al. 2020).

As part of the adaptive management program, the Action Agencies, with input from the THSC and TTT, will reevaluate implementation at 5-year intervals (see Appendix D of BPA et al. 2020). The proposed metrics after the first 5-year period may be adaptively managed, based on input from the THSC and TTT, to optimize fish benefits based on understanding of species status and population priorities, limiting factors, what actions will provide the greatest benefits, implementation considerations, etc.

For an overview of how NMFS analyzed the effects of tributary habitat improvement actions for this opinion, see Appendix A. In brief, we reviewed and re-affirmed the strong technical foundation for the tributary habitat program (i.e., that strategically implementing actions to alleviate the factors that limit the function of tributary habitat will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead). We evaluated new RME information and found that it also supported the foundation of the program. We determined that the methods we were using to evaluate the effects of tributary habitat actions were based on best available science. For steelhead, we evaluated the effects of actions qualitatively within the context of our understanding of limiting factors, the effects of the types of habitat improvement actions being proposed, population extinction risk, habitat improvement potential, and our ESA recovery plan framework. Life-cycle models for UCR steelhead are in development and were not available for use in this analysis. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered certainty of implementation and effects, as well as the strategic framework within which the Action Agencies were committing to implement the program. In addition, we considered the adequacy of the RME and adaptive management framework proposed to guide and refine implementation of the habitat improvement actions and inform our understanding of their effects, and the adequacy of the proposed reporting on actions implemented.

In this DPS, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, to reduce entrainment, to improve stream complexity, to improve access to habitat, and to improve riparian habitat. Limiting factors in this MPG include diminished stream flow, reduced stream complexity and channel structure, impaired passage and access, and degraded riparian conditions (see Section 2.7.2.4), so the actions will be targeted toward addressing these identified limiting factors.[272]

Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.7-12. The positive changes noted in the table below may contribute to improvements in all four VSP parameters for the targeted populations. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions.

Table 2.7-12. Effects and timing of effects of proposed tributary habitat improvement actions for UCR steelhead.

Action Type	Effects of action and timing of effects
Flow protection and enhancement	Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017a). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows

[272] While unscreened diversions did not rise to the level of ESU- or population-scale synthesis of current limiting factors, it is quite possible that there are local conditions where unscreened diversions are causing significant adverse effects.

Action Type	Effects of action and timing of effects
	and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Sabaton et al. 2008, Roni et al. 2014). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and the success of these projects (Roni et al. 2008). For example, ongoing studies in the Lemhi River show increased spawner and juvenile abundance of both Chinook salmon and steelhead following enhancement of instream flows in tributaries (Uthe et al. 2017, Appendix A of Griswold and Phillips 2018). The effects of flow augmentation on habitat conditions depends on the amount of flow within the channel and how much water is added. Augmented flow in dewatered channels or streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).
Improved habitat access	Impaired fish passage can prevent adults from accessing upstream spawning habitat and impede juvenile fish migration. In addition, structures that impede fish passage can disrupt habitat-forming processes related to flow, sediment transport, and large wood (NMFS 2013a, 2017a). Improving fish passage through actions that replace, improve, or remove culverts, dams, and other migration barriers, or that provide fish passage structures, can provide access to previously inaccessible spawning and rearing habitat. In addition, removing barriers can enhance habitat-forming processes related to flow, sediment transport, and movement of large wood and contribute to improvements in stream morphology, substrate, connectivity, stream flow, and stream temperature (NMFS 2013a, Hillman et al. 2016). Studies evaluating the effectiveness of projects that have removed impassable culverts/dams or have installed fish passage structures in North America and elsewhere, including in the Columbia River basin, have consistently shown rapid colonization by fishes; some studies have also documented the physical impacts of barrier removal on sediment and channel changes (Hillman et al. 2016). The rate at which salmon and trout recolonize habitats following barrier removal is highly dependent on the amount and quality of habitat upstream of the barrier, and the size of the downstream or nearby source population (number of salmon or trout returning that could colonize) (Hillman et al. 2016).
Improved stream complexity	Stream complexity created by large wood, boulders, coarse substrate, undercut banks, and overhanging vegetation (in concert with adequate flow regimes and other habitat-forming processes) is an essential feature of productive salmon habitat. Functioning floodplains and side-channels with hydrologic connectivity are also key feature of productive salmon habitat because they provide rearing, resting, and refuge habitat; increase availability of prey; and enhance other stream and watershed processes (NMFS 2013a, 2017a). Habitat improvement actions commonly implemented to enhance stream complexity include placement of large wood, boulders, and cover structures; gravel addition; floodplain reconnection; side channel and pond construction and reconnection, levee removal, and setback; channel re-meandering; and, more recently, the construction of beaver enhancement structures (Roni et al. 2014, Hillman et al. 2016). These actions can be expected to aid in reestablishment of hydrologic regimes, increase the availability of rearing habitat, improve access to rearing habitat, increase the hydrologic capacity of side channels, increase channel diversity and complexity, provide resting areas for salmonids, provide flood-water attenuation, and enhance native plant communities (NMFS 2013a). The placement of instream structures includes a wide variety of actions that can affect many different habitat factors, so salmonid responses documented in the literature are quite diverse, ranging from small negative responses to large increases in abundance, growth, and survival. Most studies indicate a positive response (increased abundance and density)

Action Type	Effects of action and timing of effects
	for salmonids. The lack of response or decrease in abundance identified in some studies was often because the projects did not address upstream watershed processes (e.g., sediment, water quality, etc.), the actions did not address the factors limiting fish, duration of monitoring was too short to demonstrate a positive effect, or the treatments resulted in little change in physical habitat. Salmonids have also been shown to respond rapidly to reconnected or constructed floodplains, side channels, and wetlands. These habitats provide critical rearing habitat for juvenile Chinook and coho salmon and steelhead. Studies indicate that these actions increase salmonid abundance, individual growth rates, overwinter survival, and smolt production (Hillman et al. 2016). While benefits of actions to improve stream complexity may be rapid in terms of fish occupying restored habitats, they also will continue to accrue over some time as habitat continues to respond.
Riparian Habitat Improvement	Riparian vegetation provides numerous functions including shading, stabilizing streambanks, controlling sediments, contributing large wood, and regulating the flow of nutrients. Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014, Hillman et al. 2016, NMFS 2017a). Benefits of riparian planting actions take more than 50 years to fully accrue, although some benefits begin to accrue after 5 to 10 years (Justice et al. 2017, Pess and Jordan, eds. 2019). Few studies have examined the response of instream habitat or fish to riparian planting or thinning, in part because of the long lag time between tree growth and any change in channel conditions or delivery of large wood. However, a retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and instream anadromous fish habitat at revegetated sites. Modeling work in the Grande Ronde River basin indicates that riparian enhancement actions should reduce water temperatures and increase juvenile salmonid abundance up to 377 percent in the Upper Grande Ronde River and 61 percent in Cather Creek (McCullough et al. 2016). Justice et al. (2017) utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River and Catherine Creek Basins in Oregon. They focused on streams that had been degraded by intensive land use leading to reduced riparian vegetation and widened channels and concluded that restoration of such streams could more than make up for expected increase in summer stream temperature through 2080. Studies of fish response to livestock exclusion projects have shown variable results. Some have shown increases in salmonid abundance while others have shown no response. Those showing no response were linked to short duration of monitoring, small size of enclosures, and upstream habitat processes that limited habitat conditions in the project area (Hillman et al. 2016).
Entrainment	Diversion of water from rivers can negatively affect salmon and steelhead populations. For example, open, unmodified water diversions can act as a source of injury or mortality to resident or migratory fishes from entrainment and impingement, and can cause habitat degradation and fragmentation. Fish-protection devices, such as exclusion screens, can physically or behaviorally deter fish from approaching or being entrained into water diversions. Most monitoring of screening projects is compliance monitoring rather than effectiveness monitoring, with a focus on whether installation or upgrading screens has reduced entrainment of fish into irrigation or water withdrawal systems. In one evaluation, however, Walters et al. (2012) conducted modeling that indicated that an extensive program to screen diversions in the Lemhi River had potentially significantly reduced mortality of outmigrating Chinook salmon smolts. Screening irrigation or water withdrawal systems and reconnecting spawning

Action Type	Effects of action and timing of effects
	and rearing streams often provide immediate and important survival and carrying capacity benefits (Hillman et al. 2016).

All four populations in this DPS must achieve at least viable status to meet the delisting goals established in the ESA recovery plan (UCSRB 2007), and there is potential for improvement in tributary habitat productivity in all four populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced (Appendix A; also see, e.g., Hillman et al. 2016, ISAB 2018, Pess and Jordan, eds. 2019).[273]

The Action Agencies have well-developed partnerships with local implementing groups in the upper Columbia River. In the upper Columbia River, the Action Agencies, in coordination with the UCRTT, utilized the Upper Columbia Biological Strategy (UCRTT 2013) to document biological considerations for the protection and improvement of habitat in the upper Columbia River. This strategy is the guiding document used by the UCRTT to evaluate proposed actions, and it provides a scientific basis for a formal process to design, select, and prioritize habitat improvement actions in an effort to achieve the highest biological benefit and ensure project goals will be met. The UCRTT intends to update the strategy periodically as new information becomes available. In addition, numerous detailed reach assessments have been completed to identify sources of stream impairment, limiting factors, and specific action opportunities. This on-the-ground infrastructure, combined with the Action Agencies' commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

Life-cycle modeling of proposed tributary habitat actions for this DPS was not available to help assess the extent of benefits of tributary habitat actions. In general, implementation of the

[273] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. NMFS' focal population concept (Cooney et al. 2020a) may inform decisions about which populations have the highest potential to benefit DPS status in the near term from directed habitat actions. However, in this case there are only four populations in the DPS, and all four are required to be at least viable to achieve ESA recovery goals. Thus, there is less utility in focusing near-term efforts on a subset of populations, and any of the four is likely an appropriate focus of near-term tributary habitat effort. Nevertheless, NMFS will work with the Action Agencies during implementation of the proposed action to evaluate opportunities for greater alignment of implementation efforts with recovery plan priorities and focal population concepts to the extent they are not currently aligned. The Action Agencies (BPA et al. 2020) indicated that initially (i.e., for the first 5-year period of their proposed action), they intend to focus tributary habitat efforts on populations where they focused effort under the 2008 biological opinion. The action agencies carried out actions in all four populations of this DPS under the 2008 biological opinion, and all four populations were designated as priority populations in that biological opinion.

tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will likely provide near-term and long-term benefits to the targeted populations by improving their tributary habitats in the manner and timeframes outlined in Table 2.6-10, above. These improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations, although based on the amount of actions proposed for this DPS, these improvements will likely be modest. Certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change (Beechie et al. 2013, McCullough et al. 2016, Justice et al. 2017). Further, Crozier et al. (2019) looked at methods of increasing climate resilience for Pacific salmon and steelhead and concluded that reducing any anthropogenic stressor could improve response to climate change by improving the overall status of an ESU or DPS (in terms of abundance, productivity, spatial structure, and diversity), thereby making the ESU or DPS more resilient and less vulnerable to stochastic extinction. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action.

2.7.3.1.9 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail in the site-specific biological opinions referenced therein (see Section 2.7.2.2). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.7.3.1.10 Predation Management

Avian Predators

Avian Predators in the Lower Columbia River Estuary

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions will continue current levels of predation at these colonies, which, in the case of Caspian terns, is an average annual reduction of 6.2 percent compared to the pre-colony management period. However, ocean conditions, including compensatory effects such as the number and behavior of predators and competition for prey, will determine whether this reduction in tern predation influences adult returns. Although there appears to have been a small to moderate decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 6.3 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, we expect that cormorant predation in the estuary may be an increasingly important source of mortality for UCR steelhead.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none have been proposed at this time

Avian Predators in the Hydrosystem Reach

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia River dams. At each dam, bird numbers will be monitored, birds foraging in dam tailraces will be hazed (including, in some circumstances, lethal reinforcement), and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas, and juvenile bypass outfall areas, will also continue. If proven biologically and cost effective, the Corps will deploy laser systems to haze birds foraging near bypass outfalls. Upgrades to existing systems, including bird wires at McNary Dam, will be coordinated through the FPOM and included in the annual Fish Passage Plans. We expect that these measures will continue to reduce predation on juvenile UCR steelhead, although Zorich et al. (2012) were unable to quantify the amount of protection.

The Action Agencies propose to continue to address Caspian tern predation on lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015 but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. These measures are likely to preclude use of Crescent Island by Caspian terns. Reclamation will continue passive and active dissuasion efforts for Caspian terns on Goose Island. They have coordinated the timing and duration of the proposed work with USFWS to ensure it will be effective in maintaining the management objectives of fewer than 40 breeding pairs at this site, consistent with the IAPMP. This ongoing suite of colony management actions is likely to continue current levels of predation by terns in the interior Columbia River basin, which is a large reduction compared to the pre-colony management period.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally-sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the hydrosystem reach are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

John Day Reservoir—Spring Operations to Reduce Predation Rates by Caspian Terns

The Action Agencies propose to hold the elevation of John Day Reservoir at 264.5 to 266.5 feet from April 10 to June 1 or no later than June 15 each year, or as feasible based on river flows, to inundate bare sand habitat and deter Caspian terns from nesting in the Blalock Islands Complex. Because foraging effort and predation rates increase once chicks hatch, the Action Agencies will begin to increase the reservoir's elevation before Caspian terns initiate nesting (i.e., operations may begin earlier than April 10). The Action Agencies will consider bird observations along with the run timing of juvenile steelhead to determine the dates each year. At the conclusion of this operation, the draft to operating range (262.5 to 264.5 feet) will be completed within 4 days. In general, 95 percent of the juvenile steelhead migration passes John Day Dam by June 1 (DART 2020m).

The timing of this operation is based on the expectation that Caspian terns will begin colonizing exposed habitat and start courtship and nest building within days to weeks of returning the reservoir to the 262.5- to 264.5-foot range. In general, chicks hatch about 27 days after eggs are laid, at which point energetic demands and fish consumption rates increase substantially. Thus, we expect that inundating bare sand habitat until most yearling steelhead pass John Day Dam will reduce predation rates on individuals from the UCR steelhead DPS.

Fish Predators

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. The current fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the numbers of steelhead, including some from the UCR steelhead DPS, handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy) will be no more than 100 adults and 600 juveniles per year. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams and will conduct test fisheries at additional dam projects on the Snake River as described in the proposed action (BPA et al. 2020). This may help to further reduce predation on juvenile salmonids, but the likelihood of the program being implemented at additional Columbia River dams (which would produce greater benefits for UCR steelhead) is not reasonably certain to occur. We estimate that no more than 10 adult and 20 juvenile steelhead, including some from the UCR steelhead DPS, will be caught in the Dam Angling Program per year.

These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including UCR steelhead.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea lion exclusion devices at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and BPA will continue to support harassment and removal efforts to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace. Through the FPOM and Sea Lion Task Force, the Corps will continue to use adaptive management to address changing circumstances as they relate to supporting sea lion harassment efforts and monitoring of sea lion predation at Bonneville Dam. These ongoing measures are expected to maintain or reduce current levels of sea lion predation on UCR steelhead in the Bonneville tailrace, which is currently estimated at 1.6 percent. If pinnipeds are observed at The Dalles Dam, the Corps may respond with hazing at adult fish ladder entrances.

2.7.3.1.11 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult UCR steelhead are likely to be present in shallow shoreline areas, an unknown portion of the DPS will continue to be stunned, harmed or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this DPS that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[274]

The level of RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of UCR steelhead will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS:
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - 11,500 hatchery and 7,000 natural-origin juveniles will be handled.
  - 23 hatchery and 140 natural-origin juveniles will die.
- Activities associated with all other RME programs:
  - 300 hatchery and 300 natural-origin adults will be handled.
  - 10 hatchery and 10 natural-origin adults will die.
  - 5,500 hatchery and 9,000 natural-origin juveniles will be handled.
  - 214 hatchery and 70 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program is expected to affect, on average, up to 9.4 percent of the natural-origin adult run (recent, 5-year average arriving at Priest Rapids Dam) and up to 7.7 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020).The effects of RME

[274] Ongoing and future discussions are expected to lead to substantial reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to less than 1 percent of estimated DPS abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the effects of the RME programs on abundance are acceptable and warranted.

2.7.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small reduction in obstructions for juvenile inriver migrants at the four mainstem dams in the lower Columbia River. However, these increased spill levels are likely to cause eddies to form at John Day Dam under low flow conditions, increasing obstructions by a small amount at that project. Few adult UCR steelhead will be migrating during the spring spill operation, but those that do are likely to experience an increased rate of involuntary fallback over the spillway (small increase in obstructions). Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.7-13.

Table 2.7-13. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the UCR steelhead DPS.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning sites and freshwater rearing sites	The Action Agencies will implement tributary habitat improvements to achieve the MPG-level metrics outlined in Table 2.7-11. These actions are likely to improve water quality (e.g., temperature), water quantity, substrate, floodplain connectivity, forage, and natural cover at the local scale in watersheds with spawning and rearing sites. After the first 5-year period, the proposed metrics may be adaptively managed to optimize fish benefits and the functioning of spawning and rearing sites.
Freshwater migration corridors	*Effects in the migration corridors apply to all populations of UCR steelhead:* Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. Proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not change the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and early summer and warmer temperatures in the late summer and fall. Most adult UCR steelhead enter the lower Columbia River during summer and fall and will be exposed to the warmer mainstem temperatures (degraded water quality in the migration corridor).

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume, which may reduce "natural cover" in the migration corridor for all populations. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill at the CRS run-of-river projects in the lower Columbia River. The effect on water quality in terms of an increase in the incidence of GBT is likely to be very small. The Corps will continue to protect water quality by using best management practices to minimize accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. The flexible spring operation to 125 percent TDG will increase obstructions in the adult migration corridor by a very small amount by increasing the risk of fallback over project spillways and by degrading tailrace hydraulic conditions at John Day Dam for steelhead that overwinter in the lower Columbia River and migrate upstream in the spring. The flexible spring spill operation to 125 percent TDG will reduce obstructions in the juvenile migration corridor by a small amount by increasing the likelihood of spillway passage. However, the increased spill levels that are likely to degrade tailrace conditions at John Day Dam (obstructions in the migration corridor), are also likely to increase the risk of bird and fish predation. Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions for juveniles and adults by a small amount because some will pass downstream or fall back through a turbine unit. Increased operating range for John Day Reservoir will reduce the risk of avian predation by a moderate amount while increasing juvenile travel times by a small amount (moderate reduction in excessive predation and slight increase in obstructions). Continued small increases in obstructions for adult steelhead during routine outages of fishways or turbine units. Very small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities (e.g., to upgrade turbines at Ice Harbor, McNary, and John Day Dams and for a major repair such as the jetty and retaining wall at Little Goose Dam). Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Long-term effect of turbine upgrades will be reduced obstructions (improved turbine survival). Repairing the jetty at Little Goose Dam will also reduce obstructions for adults at that project. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	Continued implementation of the Action Agencies' bird, fish, and pinniped predator management programs will continue recent levels of predation risk in the juvenile and adult migration corridors.
Estuarine areas	*Effects in estuarine areas apply to all populations of UCR steelhead:* Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels and juvenile and adult forage. This will increase access to prey for yearling steelhead that remain in the mainstem. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.7.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.7.1), Environmental Baseline (Section 2.7.2), and Effects of the Action (Section 2.7.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules;

stormwater and discharge regulation; TMDL implementation to achieve water quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including UCR steelhead.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired) and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.7.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.7.3) to the environmental baseline (Section 2.7.2) and the cumulative effects (Section 2.7.4), taking into account the status of the species and critical habitat (Section 2.7.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.7.5.1 Species

The UCR steelhead DPS comprises a single MPG that includes four populations originating below natural and manmade barriers in the Wenatchee, Entiat, Methow, and Okanogan Rivers, Two additional steelhead MPGs likely spawned above Grand Coulee and Chief Joseph Dams, but these MPGs are extirpated. The most recent 5-year status review indicated that there have been improvements in natural-origin abundance, but the populations are rated at high risk, with the exception of the Wenatchee River population, which is rated as maintained. All four populations need to achieve viable status for the DPS to be delisted. Excepting the Methow River population, recent adult returns (2014 to 2018) for each of the three populations have been substantially (21 to 53 percent) below 2009 to 2013 returns. This downturn is associated with a marine heatwave and its lingering effects, which likely contributed to substantially lower ocean survival rates of juvenile steelhead. Some of these negative effects had subsided by spring 2018 and expectations for marine survival were mixed for 2019 outmigrants.

UCR steelhead pass the four lower Columbia River mainstem dams, as well as three (Wenatchee River), four (Entiat River), or five (Methow and Okanogan River) FERC-licensed mainstem dams in Columbia River located between McNary and Chief Joseph Dams. Conditions for UCR steelhead populations have generally improved in the mainstem Columbia River because of the installation and operation of surface passage routes, 24-hour spill, improved spill patterns, and improvements to the juvenile bypass systems at the mainstem dams. McNary to Bonneville Dam survival rates for ESA-listed hatchery and natural-origin UCR steelhead vary substantially, but have averaged about 78 percent the past 10 years (2010 through 2019) (Zabel 2019, Widener et al. 2020). Performance standards testing at the mid-Columbia PUD FERC-licensed projects indicates that recent average juvenile survival rates to the Priest Rapids tailrace are about 78 percent for juveniles from the Okanogan and Methow Rivers (five reservoirs and dams), 81 percent for juveniles from the Entiat River (four reservoirs and dams), and 85 percent for juveniles from the Wenatchee River (three reservoirs and dams).

The juvenile survival rates from the FERC-licensed mainstem dams to McNary Dam and from McNary Dam to Bonneville Dam include all sources of mortality, even those that are not caused by the past or proposed operation and maintenance of the CRS. For instance, regardless of the operational or configurational choices made for the hydrosystem, some predation and other natural mortality of juvenile UCR steelhead would occur during their migration. In addition, juvenile survival is influenced by past and present alterations of shoreline habitat, among other stressors, unrelated to the effects of operating the hydrosystem; many of those effects will continue into the future. We are unable to differentiate the proportion of the losses that result from the operation and maintenance of the mainstem dams rather than to the existence of the dams, but we know that the mortality attributable to operations and maintenance is less than the losses captured in the overall survival estimates. As discussed further below, some also hypothesize that passage through juvenile bypass systems and turbines causes latent mortality, which would not be captured in the direct survival estimates.

Adult survival rates (adjusted to account for reported harvest and typical straying rates), include “natural” mortality as well as any mortality associated with injuries incurred from predators. Adult survival rates for UCR steelhead are relatively high, averaging about 92 percent from Bonneville and McNary Dam, 95 percent from McNary to Priest Rapids, and 96 percent from Priest Rapids to Wells Dam. Few adult UCR steelhead should be affected by increased spring spill levels because they predominantly migrate in the summer and fall. For those few that pass lower Columbia River dams in the spring, although increased spring spill levels at some of the dams are expected to slightly increase adult fallback rates, associated mortalities should be offset by adults falling back through spillbays (which have higher survival rates than juvenile bypass systems or turbine units).

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Overall, scheduled maintenance activities are expected to continue to negatively affect small numbers of adult UCR steelhead annually. A few adults will die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. Very few juveniles are likely to be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled. Non-routine and unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the inseason adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative spill or turbine unit priorities) will likely minimize these impacts.

The proposed spring spill levels utilize a program of voluntary fish passage spill with the highest spill volumes ever implemented. This will increase juvenile exposure to higher TDG levels; however, it is unlikely that spilling up to 125 percent TDG for 16 hours per day at mainstem dams will result in any substantial, negative impacts to juvenile survival (or adult passage) because there are sufficient data and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). The potential for negative effects from increased TDG may be greater for juvenile steelhead than for other species because they tend to migrate higher in the water column; however, they typically occur deeper than 1 to 2 meters from the surface so depth compensation would still ameliorate effects of high TDG. In 2020, implementation of spring spill up to 125 percent TDG did not cause GBT symptoms at levels of concern. In addition, there is sufficient monitoring and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). The proposed 125 percent flexible spill operation could slightly improve direct juvenile survival rates through the four lower Columbia river mainstem projects (with the possible exception of Bonneville Dam, where survival rates could decrease slightly, and at The Dalles Dam, which will maintain spill levels of 40 percent), although the COMPASS modeling comparing the Preferred Alternative to the No Action Alternative suggested there would be no benefit (USACE et. al. 2020). The CSS model predicts more substantial increases in juvenile survival, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillbays) will increase adult returns of the Snake River populations by about 28 percent. If this is the case, to the extent that UCR steelhead experience latent mortality associated with dams, higher spill levels would be expected to increase adult returns accordingly, but likely by no more than half (14 percent) that hypothesized by the CSS for SRB steelhead (28 percent) because they pass through half as many Federal projects. If these predictions are realized, they would represent a near-term improvement in productivity and abundance for UCR steelhead and, over time, would somewhat reduce the severity of expected declines in abundance and productivity caused by a warming climate and deteriorating ocean conditions.

Tributary habitat conditions for UCR steelhead are generally good in high elevation reaches but degraded in lower elevation reaches, particularly near valley bottoms, as a result of past and present land uses. Generally, the ability of tributary habitat to support the viability of UCR steelhead is limited by one or more of the following factors: 1) reduced stream complexity and channel structure, 2) reduced floodplain condition and connectivity, 3) degraded riparian conditions, 4) diminished stream flow, 5) impaired fish passage, 6) excess fine sediment, and 7) elevated summer water temperatures.

Many habitat improvement actions have been implemented in the subbasins occupied by UCR steelhead (i.e., the Wenatchee, Entiat, Methow, and Okanogan subbasins). These actions have been targeted toward addressing limiting factors and have included protecting and improving stream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. NMFS has determined that these actions have improved, and will continue to improve, habitat in the targeted populations as these projects mature, and that fish population abundance, productivity, spatial structure, and diversity will respond positively. The benefits of some of these actions will continue to accrue over several decades. At the same time, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

While some degraded tributary habitats in the UCR steelhead DPS are likely on an improving trend, in general tributary habitat conditions are still degraded. These degraded habitat conditions continue to negatively affect UCR steelhead abundance, productivity, spatial structure, and diversity. There remains additional potential for improvement in habitat productivity in all four populations, and additional tributary habitat improvements are needed to achieve recovery goals.

Implementation of the tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will provide additional near-term and long-term benefits to the targeted populations by improving tributary habitat in the manner and timeframes outlined in Table 2.7-12, above. In addition, certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change (Beechie et al. 2013, McCullough et al. 2016, Justice et al. 2017). Crozier et al. (2019) looked at methods of increasing climate resilience in their 2019 climate vulnerability assessment for Pacific salmon and steelhead. They found that reducing anthropogenic stressors could greatly improve responses to climate change by improving the overall status of a DPS in terms of abundance, productivity, spatial structure, and diversity. A robust DPS has greater resilience by virtue of strong population dynamics that make stochastic extinction less likely. Actions implemented to ameliorate limiting factors for any population would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced.

These improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action. Further, to yield substantial improvements, it is necessary to implement a large scale and scope of habitat improvement actions (e.g., implementation over a 25-year time period or longer), and to implement actions throughout a large portion of each watershed. Thus, it is important to consider the results of the habitat actions to be implemented under this proposed action in the context of the effects of long-term implementation of habitat actions.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving UCR steelhead abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this DPS. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan, the Double-crested Cormorant Management Plan, and the IAPMP, as well as hazing at the mainstem dams. For UCR steelhead, we expect that management of tern colonies throughout the basin is reducing mortality by a moderate amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. And cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that prey on steelhead smolts are also present in the hydrosystem reach. Increasing the John Day reservoir elevation in the spring should control impacts from the Blalock Islands tern colony. The NPMP and dam angling program are expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested Cormorant Management Plan, these programs will maintain current (reduced) levels of predation, which creates conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

The largest harvest-related effects on UCR steelhead result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery and estimated that harvest rates would continue to average around 10 percent (including an estimated 10 percent mortality of wild-released fish). In addition, small fisheries operate in the Columbia River basin (above McNary Dam). Fisheries for non-ESA-listed fish also occur that may have incidental impacts on UCR steelhead. Together, the impact to natural-origin adults should be less than 12 percent (the estimated maximum impact of all hatchery program operation, tributary harvest, and research and monitoring, combined).

Pinniped predation on UCR steelhead in the lower Columbia River and estuary has increased slightly with recent increases in the abundance of steller sea lions in the summer and fall. Losses in the Bonneville tailrace remain relatively low, averaging a little more than 1 percent. Sea lion predation downstream of Bonneville Dam, including the estuary, continues to negatively affect the productivity and abundance of UCR steelhead.

The past effects of artificial production programs have largely been to increase abundance and help preserve genetic resources—especially true for safety net or conservation hatchery programs during times of low abundance. However, these programs have also posed risks to natural productivity and genetic diversity. The management of UCR steelhead hatchery programs has generally improved substantially compared to historical operations. Recently authorized HGMPs will minimize impacts to naturally produced populations within this ESU, but these benefits may not be fully realized for several generations of fish. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of UCR steelhead. Additionally, the The Confederated Tribes of the Colville Reservation (CTCR) operate a kelt reconditioning program in the Okanogan subbasin and the Yakama Confederated Tribes operate a kelt reconditioning program in the upper Columbia River basin as well. While these programs produce relatively few repeat spawning adults annually, they can represent a substantial fraction of the spawning females in poor return years, improving abundance and productivity during these times.

As described in Section 2.8.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect UCR steelhead in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of UCR steelhead as high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change. However, the severity of those changes would be somewhat reduced as a result of the proposed action.

Summer-run adults could potentially respond temporally to changing environmental conditions by migrating and spawning later in time. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or flood events). Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in streams. Juveniles would be exposed to higher summer temperatures in tributaries, though juvenile migrants could potentially respond temporally by migrating earlier in the spring. Though the quality of information is mixed, sensitivity in the marine stage is certainly high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur. These climate change consequences, which will make recovery of this DPS more challenging, are not caused by the proposed action, and elements of the proposed action (tributary and estuary habitat restoration and research, monitoring, and evaluation programs) should help to improve the resiliency of UCR steelhead populations to expected climate change.

The proposed action—the future operation of the CRS (including Upper Columbia River operations to better protect resident species and Dworshak Dam winter operations to reduce TDG in the lower Clearwater River)—will have little overall effect on the seasonal hydrograph or seasonal temperatures compared to recent conditions. The seasonal hydrograph will continue to be altered, generally increasing flows in the fall and winter and reducing flows in the spring. Seasonal water temperatures will also continue to be altered, with delayed warming in the spring, delayed cooling in the fall, and reduced daily temperature variability. These effects to river conditions likely adversely affect the survival of UCR steelhead, but to an extent not readily quantified based upon the best available information.

Other operations (e.g., operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, increasing the John Day reservoir operating range during the spring to reduce avian predation, etc.) are, collectively, expected to have small negative effects, especially on juvenile migrants, but these effects should not measurably alter survival estimates between McNary Dam and Bonneville Dam.

The proposed action includes many measures to reduce the adverse effects of the passage impediments caused by the existence of the CRS, including juvenile fish passage spill, operation of juvenile bypass systems, attraction flows for adults, and operation of adult fish ladders. In addition to these measures, if the flexible spring spill operation increases adult returns by up to 14 percent (half that hypothesized by the CSS for SRB steelhead), UCR steelhead would experience a substantial near-term improvement in productivity and adult abundance over current conditions.

Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this DPS (e.g., population productivity, degraded tributary and estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.).

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity and likely affects marine survival (to an unknown extent) through latent mortality. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., tributary and estuary habitat, predation, etc.). Evidence shows that these actions have resulted in improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The recent downturn in adult abundance (2014 to 2019) is primarily the result of recent poor ocean conditions and not of altered tributary and mainstem habitat conditions. The proposed action carries forward structural and operational improvements since 2008 and improves upon them. Potential improvements resulting from reduced latent mortality are possible, and ecosystem functions should continue to increase in tributary and estuary habitats where improvement actions occur.

Climate change is a substantial threat to UCR steelhead, especially during the marine rearing phase of their life cycle. The proposed action should not exacerbate either the scope and/or severity of those impacts.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of UCR steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of UCR steelhead.

2.7.5.2 Critical Habitat

NMFS designated critical habitat for UCR steelhead to include all estuarine areas and river reaches of the mainstem Columbia River and its tributaries upstream of Rock Island Dam and downstream of Chief Joseph Dam, including the Okanogan River subbasin. Across subbasins with PBFs for UCR steelhead in the Interior Columbia Recovery Domain, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web); reduced water quality; and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use and water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

Measures taken through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies, in the decades since critical habitat was designated have improved the functioning of spawning and rearing area PBFs. These include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. However, more improvements will be needed before many areas function at a level that supports the recovery of UCR steelhead. Under the proposed action, the Action Agencies will implement a suite of habitat actions to further improve the functioning of water quantity, water quality (e.g., temperature), substrate, floodplain connectivity, forage, and natural cover at the local scale in watersheds with spawning and rearing sites. These include enhancing flow; access; stream complexity, including floodplain connectivity; and riparian function; and screening diversions in one or more populations in the DPS. Climate change is likely to decrease streamflow (water quantity) and increase temperature (water quality) in some spawning and rearing areas, depending on their specific characteristics and locations. These risks underscore the importance of the Action Agencies' habitat restoration program, especially actions that restore riparian vegetation, streamflow and floodplain function, to improve habitat resiliency.

The environmental baseline also includes a broad range of past and present actions and activities, including effects of the hydrosystem that have affected the conservation value of critical habitat in freshwater migration corridors for UCR steelhead. Some of these past effects of CRS operations will continue under the proposed action: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and passage delays (obstructions in the juvenile migration corridor). These factors have increased the likelihood of excessive predation on juvenile and adult UCR steelhead and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The proposed action carries forward structural and operational improvements since 2008 that address these effects on PBFs and in some cases, improves upon them. To address these effects on PBFs, the Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors.

The Action Agencies also have reduced effects of their operations on juvenile salmonid travel time and survival by increasing levels of spring spill. We expect the additional flexible spring spill to 125 percent TDG to reduce water quality in the juvenile migration corridor by a small amount while having a small positive effect on obstructions at CRS projects in the lower Columbia River through increased spillway passage. On the other hand, in low runoff years, higher spill levels could degrade tailrace conditions at John Day Dam, increasing the risk of bird and fish predation for juvenile migrants. However, there is sufficient flexibility through the in-season management process to identify and remedy negative effects through modified spill patterns.

Operating turbines above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction for adults (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions by a small amount because some adults will fall back or juveniles will move downstream through turbines.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors.

In summary, the proposed action is not likely to further limit water quantity or water quality or to increase obstructions in the juvenile or adult migration corridors by a meaningful amount. In addition, if the CSS hypothesis regarding latent mortality is correct, the flexible spill program could improve the functioning of the juvenile migration corridor to a greater extent than indicated by the likely effects on obstructions described above.

Increasing the elevation of John Day Reservoir to cover nesting areas on the Blalock Islands will limit the risk of predation by Caspian terns by delaying nesting until about 95 percent of steelhead outmigrants have passed McNary Dam. The Action Agencies also will continue to implement measures to reduce pinniped predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the hydrosystem and the estuary, and the predation management programs for Caspian terns on the interior plateau and for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will maintain the reduced levels of predation within the juvenile and adult migration corridors that were achieved in recent years, although cormorant predation rates may further increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the estuary, many of these funded through the CRS program. The Action Agencies propose to continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling steelhead migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action will not appreciably diminish the value of designated critical habitat as a whole for the conservation of UCR steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of UCR steelhead designated critical habitat.

2.7.6 Conclusion

After reviewing and analyzing the current status of UCR steelhead and its critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of UCR steelhead or destroy or adversely modify its designated critical habitat.

2.8 Middle Columbia River (MCR) Steelhead

This section applies the analytical framework described in Section 2.1 to the MCR steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the MCR steelhead DPS or destroy or adversely modify its critical habitat.

2.8.1 Rangewide Status of the Species and Critical Habitat

The status of the MCR steelhead DPS is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.8.1.1 Status of the Species

2.8.1.1.1 Background

On March 25, 1999, NMFS listed the MCR steelhead DPS as a threatened species (64 FR 14517). The threatened status was reaffirmed on January 5, 2006 (71 FR 834). The most recent status review, in 2016, concluded the species should remain listed as a threatened species (81 FR 33468). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52630). The summary that follows describes the rangewide status of MCR steelhead. More information can be found in the recovery plan (NMFS 2009a) and the most recent status review for this species (NMFS 2016g).[275]

The MCR steelhead DPS includes all naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) to and including the Yakima River (Figure 2.8-1). The DPS comprises 20 historical populations (three of which are extirpated) grouped into four MPGs. It also includes steelhead from seven artificial propagation programs (Table 2.8-1) (71 FR 834).[276]This DPS does not include steelhead in the upper Deschutes River basin, which are designated as part of an experimental population (79 FR 20802, 76 FR 28715).

[275] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

[276] For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species (81 FR 72759). No changes were proposed for the Mid-Columbia steelhead DPS. We expect to publish the final revisions in 2020.

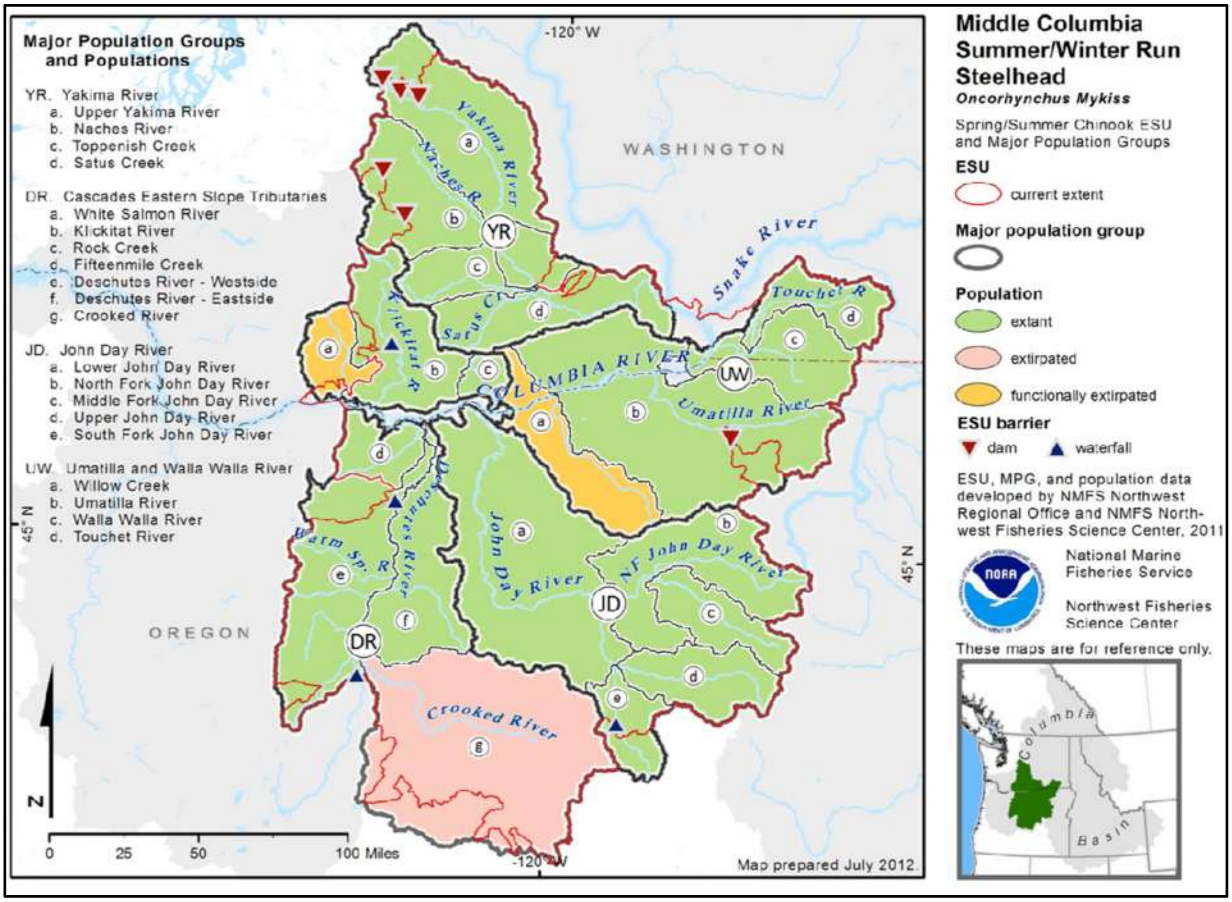

Figure 2.8-1. Map illustrating MCR steelhead DPS's populations and major population groups. Source: NWFSC 2015.

Table 2.8-1. MCR steelhead DPS major population groups and component populations, and hatchery programs (NMFS 2009a, 71 FR 834). Populations with * are winter-run steelhead populations. All other populations are summer-run steelhead populations.

Major Population Group (MPG)	***Populations***
Cascades Eastern Slope Tributaries	Deschutes River Eastside Deschutes River Westside Fifteenmile Creek* Klickitat River* Rock Creek* White Salmon* (extirpated) Deschutes Crooked River (extirpated)
John Day River	John Day River Lower Mainstem Tributaries John Day River Upper Mainstem Tributaries North Fork John Day River Middle Fork John Day River South Fork John Day River
Yakima River	Naches River Satus Creek Toppenish Creek Yakima River Upstream Mainstem
Umatilla/Walla Walla Rivers	Touchet River Umatilla River Walla Walla River

Major Population Group (MPG)	*Populations*
	Willow Creek (extirpated)
Hatchery Programs	
Hatchery programs included in DPS	Touchet River Endemic Yakima River Kelt Reconditioning (four programs: Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River) Umatilla River Program Deschutes River Program

2.8.1.1.2 Life History and Factors for Decline

The MCR steelhead DPS includes 16 summer-run populations and four winter-run populations. Summer steelhead enter freshwater between May and October and require several months to mature before spawning; winter steelhead enter freshwater between November and April and spawn shortly thereafter. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Summer steelhead usually spawn farther upstream than winter steelhead (NMFS 2009a). Steelhead may enter streams and arrive at spawning grounds weeks or months (and even up to a year) before they spawn. They are therefore vulnerable to disturbance and predation. They need cover, in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity. Once in the river, steelhead apparently rarely eat and grow little, if at all (NMFS 2009a).

Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months before hatching. Young steelhead typically rear in streams for some time (generally 2 years) before migrating to the ocean. Some juveniles move downstream to rear in larger tributaries and mainstem rivers. Most fish in this DPS spend 1 to 2 years in saltwater before re-entering freshwater (NMFS 2009a). Steelhead are iteroparous, meaning they can spawn more than once, whereas all other *Oncorhynchus* except cutthroat trout (*O. clarki*) spawn once and then die (i.e., are semelparous). Repeat spawning for Columbia River basin steelhead ranges from reported rates of 2 to 4 percent above McNary Dam (Busby et al. 1996) to 17 percent in the unimpounded tributaries below Bonneville Dam (at RM 146.1) (Leider et al. 1986).

Estimates of historical (pre-1960s) abundance indicate that the total historical run size for this DPS might have been in excess of 300,000. Total run sizes for the major steelhead stocks above Bonneville Dam were estimated in the early 1980s to be approximately 4,000 winter steelhead and 210,000 summer steelhead. Based on dam counts for this period, the MCR steelhead DPS represented the majority of this total run estimate, so the returns to this DPS were probably somewhat below 200,000 at that time. It was also estimated that 74 percent of the returns to this DPS were of hatchery origin at that time (61 FR 41541). NMFS continued to note concerns about declining abundance (including in John Day River basin, the largest producer of natural-origin steelhead) (NMFS 1996). The destruction and modification of habitat, overutilization for recreational purposes, impacts of hydropower development and operation, and high percentages of hatchery fish spawning naturally were cited as factors for decline for MCR steelhead at the time of listing (71 FR 834).

2.8.1.1.3 Recovery Plan

The ESA recovery plan for MCR steelhead (NMFS 2009a) includes delisting criteria for the DPS, along with identification of factors currently limiting its recovery, and management actions necessary to achieve delisting. The biological delisting criteria are based on recommendations by the ICTRT.[277] They are hierarchical in nature, with DPS-level criteria based on the status of natural-origin MCR steelhead assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the DPS will require sufficient improvement in the abundance, productivity, spatial structure, and diversity of its component populations. Table 2.8-2 shows population status as of the most recent 5-year status review (NMFS 2016g) and the options for target status for each population to meet delisting criteria, based on the recovery plan (NMFS 2009a) and the ICTRT recommendations.

Table 2.8-2. Population status as of the most recent status review (NMFS 2016g) and recovery plan target status (NMFS 2009a) for MCR steelhead populations. "?" reflects uncertainty in the ratings.

MPG	Population	Population Status (Overall viability rating)	Recovery Plan Proposed Target Status
Eastern Cascades	Fifteen Mile Creek	Maintained	The Klickitat River, Fifteenmile Creek, Deschutes River Eastside, and Deschutes River Westside populations should reach at least viable status. At least one of these should be highly viable, consistent with ICTRT recommendations. MPG viability would be further bolstered if reintroduction of steelhead into the Crooked River succeeds and if the White Salmon River population successfully recolonizes its historical habitat following the removal of Condit Dam.
	Deschutes (Westside)	High Risk	
	Deschutes (Eastside)	Viable	
	Klickitat River	Maintained (?)	
	Rock Creek	High Risk (?)	
	Crooked River	Extirpated	
	White Salmon River	Extirpated	
Yakima River	Satus Creek	Viable	Two populations should achieve viable status, including at least one of the two classified as large (the Naches River and the Yakima River Upper Mainstem). The remaining two populations should, at a minimum, meet the maintained criteria. At least one population should be highly viable, consistent with ICTRT recommendations.
	Toppenish Creek	Viable	
	Naches River	Moderate	
	Upper Yakima River	High Risk	

[277] The recovery plan also includes "threats criteria" for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

MPG	Population	Population Status (Overall viability rating)	Recovery Plan Proposed Target Status
John Day River	Lower John Day Tributaries	Maintained	The John Day River Lower Mainstem Tributaries, North Fork John Day River, and either the Middle Fork John Day River or the John Day River Upper Mainstem populations should achieve at least viable status. At least one population should be highly viable, consistent with ICTRT recommendations.
	Middle Fork John Day	Viable	
	North Fork John Day	Highly Viable	
	South Fork John Day	Viable	
	Upper John Day	Maintained	
Umatilla/Walla Walla	Umatilla River	Maintained	Two populations should meet viability criteria, and at least one population should be highly viable, consistent with ICTRT recommendations. The Umatilla River is the only large population, and therefore needs to be viable. In addition, either the Walla Walla River or Touchet River population also needs to be viable.
	Walla Walla River	Maintained	
	Touchet River	High Risk	
	Willow Creek	Extirpated	

2.8.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within the DPS based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the ICTRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low risk. Generally, each MPG must achieve low risk for the DPS as a whole to be considered no longer threatened or endangered.

The most recent status review (NWFSC 2015, NMFS 2016g) found that for almost all populations in this DPS, the most recent 5-year geomean for natural-origin abundance had increased relative to the previous 5-year review.[278] Similarly, 15-year trends were positive for most populations in the DPS.[279] Populations in all four of the MCR steelhead MPGs exhibited similar temporal patterns in brood year returns per spawner: return rates for brood years 1995 to 1999 generally exceeded replacement but were generally well below replacement for brood years 2001 to 2003. Brood year return rates reflect the combined impacts of year-to-year patterns in marine life history stages, upstream and downstream passage survival, and density-dependent effects resulting from capacity or survival limitations on tributary spawning or juvenile rearing

[278] For all five populations in the John Day MPG, for all four populations in the Yakima River MPG, for all three populations in the Umatilla Walla Walla MPG; and for two of the three populations for which data were available in the East Cascade MPG.

[279] For four of five populations in the John Day MPG, all four populations in the Yakima River MPG, one population in the Umatilla/Walla Walla River MPG (a second population had a slightly negative trend and data were insufficient for the third); and for one of three populations with available data in the East Cascade MPG.

habitats. Overall, most populations showed increases in estimates of productivity. All but two populations (the Westside Deschutes River and Touchet River populations) were considered at either low or moderate risk for abundance and productivity (Table 2.8-3).

Updated information on spawner and juvenile rearing distribution for the most recent status review revealed no changes since the previous review, with all populations remaining at low or moderate risk for spatial structure. Status indicators for population diversity had changed for some populations, although in most cases the changes were not sufficient to shift composite risk ratings for a particular population, and all populations but one (the Upper Yakima River population) were rated at low or moderate risk for combined spatial structure and diversity (Table 2.8-3).

The most recent status review (NWFSC 2015, NMFS 2016g) concluded that the MCR steelhead DPS was at moderate risk and remained threatened. While there had been improvements in the extinction risk for some populations, and while several populations were considered viable, the MCR steelhead DPS as a whole was not meeting delisting criteria, and most risk ratings remained unchanged from the previous review. The increases in abundance and productivity needed to achieve recovery goals for MCR steelhead were generally smaller than those needed for the other interior Columbia River basin-listed DPSs (NWFSC 2015).

Table 2.8-3 shows abundance, productivity, spatial structure, and diversity risk ratings for the 17 populations in the DPS as of the time of the most recent status review (NWFSC 2015, NMFS 2016g).

Table 2.8-3. MCR steelhead population-level risk for abundance/productivity (A/P), diversity, integrated spatial structure/diversity (SS/D), and overall status as of the most recent status review (NWFSC 2015). Risk ratings ranged from very low (VL), to low (L), moderate (M), high (H), very high (VH), and extirpated (E). Maintained (MT) population status indicates that the population does not meet the criteria for a viable (low risk) population but does support ecological functions and preserve options for recovery of the DPS. "?" reflects uncertainty in the ratings.

Population	ICTRT Minimum Abundance Threshold[1]	Integrated A/P Risk Rating	Diversity Risk Rating	Integrated SS/D Risk Rating	Overall Extinction Risk Rating
Eastern Cascades MPG					
Fifteenmile Creek	500	M	L	L	MT
Westside Deschutes River	1,500	H	M	M	H
Eastside Deschutes River	1,000	L	M	M	L (Viable)
Klickitat River	1,000	M??	M	M	MT?
Rock Creek	500	NA	M	M	H?

Population	ICTRT Minimum Abundance Threshold[1]	Integrated A/P Risk Rating	Diversity Risk Rating	Integrated SS/D Risk Rating	Overall Extinction Risk Rating
Crooked River	2,000	E	E	E	E
White Salmon River	500	E	E	E	E
Yakima River MPG					
Satus Creek	1,000	L	M	M	L (Viable)
Toppenish Creek	500	L	M	M	L (Viable)
Naches River	1,500	M	M	M	M
Upper Yakima River	1,500	M	H	H	H
John Day River MPG					
Lower John Day tributaries	2,250	M	M	M	MT
Middle Fork John Day	1,000	L	M	M	L (Viable)
North Fork John Day	1,000	VL	L	L	VL (Highly viable)
South Fork John Day	500	L	M	M	L (Viable)
Upper John Day Mainstem	1,000	M	M	M	MT
Umatilla/Walla Walla MPG					
Umatilla River	1,500	M	M	M	MT
Walla Walla River	1,000	M	M	M	MT
Touchet River	1,000	H	M	M	H
Willow Creek	NA	E	E	E	E

[1] Minimum abundance thresholds represent the number of spawners needed for a population of a given size category to achieve low risk (viability) at a given productivity (ICTRT 2007). See NMFS (2009a) for additional detail relevant to specific populations.

2.8.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the MCR steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. Limiting factors identified in the recovery plan (NMFS 2009a) for this ESU include (in no particular order):

- Habitat degradation: While some streams and stream reaches retain highly functional habitat conditions, nearly all historical MCR steelhead habitat lies within areas modified by human settlement and activities. These various activities have degraded streams and stream reaches across the range of the MCR steelhead DPS, leaving them with degraded floodplain connectivity and function, degraded riparian areas, insufficient large wood in channels, insufficient instream complexity and roughness, and inadequate connectivity to associated wetlands and off-channel habitats. The Columbia River estuary also provides important migratory habitat for MCR steelhead populations, and estuary habitat has been lost or significantly altered since the late 1800s, and despite recent work to restore tidal wetlands, the production of wetland macrodetritus supporting salmonid food webs is reduced both in shallow water and for larger juveniles migrating in the mainstem.
- Hydropower systems: Development and operation of the mainstem Columbia River hydropower system significantly alters travel conditions in the mainstem Columbia River, resulting in direct mortality of both upstream migrating adults and downstream migrating steelhead kelts, and direct and indirect mortality for downstream migrating juveniles. The hydropower system also changes the hydrograph, depleting historically available nutrients, changing water temperatures, and degrading rearing and food resources for both presmolts and smolts. Changes in the hydrograph leave MCR steelhead more vulnerable to bird and fish predation in the Columbia River estuary and mainstem. Several hydropower dams on Columbia River tributaries also pose threats to specific populations.
- Hatcheries: Hatchery fish that stray into middle Columbia River tributaries and spawn naturally may represent a serious threat to steelhead recovery. In particular, hatchery programs designed to return summer steelhead to upstream Columbia River tributaries result in substantial numbers of stray hatchery steelhead spawning naturally among several middle Columbia River populations. While some hatchery programs may provide conservation benefits, hatchery-induced genetic change can reduce the fitness of both hatchery and natural-origin fish in the wild, hatchery fish can compete for food and space with natural-origin fish.
- Harvest: Given current management regimes, the recovery plan did not identify harvest as a primary limiting factor for MCR steelhead.
- Predation: Anthropogenic changes in the Columbia River have altered the relationships between salmonids and other fish, bird, and pinniped species, and the recovery plan identified predation as a concern for juvenile and adult MCR steelhead. The plan noted

that avian predation is a factor not only in the estuary but also farther inland, on islands in the middle Columbia River region. Predation by nonnative species was also identified as a significant factor. Predation by pinnipeds was not considered a primary limiting factor based on the relatively low numbers of MCR steelhead passing Bonneville Dam during the winter months.

- Climate change was also identified as a significant threat to MCR steelhead.

In its most recent status review NMFS (2016g) noted that:

- The many habitat restoration and protection efforts made in Columbia River tributaries and the estuary should result eventually in improved survival for the DPS, but additional improvements are needed to achieve recovery.
- Direct survival of juvenile salmonids outmigrating from MCR steelhead populations has increased as a result of juvenile passage improvements at Federal Columbia River mainstem dams. In addition, significant changes have been made at tributary hydropower projects, including passage improvements at Portland General Electric's Pelton Round Butte Project on the Deschutes River and the removal of PacifiCorp's Condit Dam on the White Salmon River. These actions are expected to benefit the DPS.
- Harvest rates remained relatively stable, with an overall exploitation rate of less than 10 percent for all fisheries combined.
- Hatchery programs continued to release hatchery steelhead and salmon within the DPS, and hatchery practices and impacts on the natural-origin populations had not changed significantly since the last review.
- Avian and pinniped predation on MCR steelhead had increased since the previous status review.
- Some regulatory mechanisms had improved since the previous status review, but, particularly for land-use regulatory mechanisms, there was lack of documentation or analysis of their effectiveness.
- Climate change was a concern, particularly the future effects of continued warming in marine and freshwater systems.

2.8.1.1.6 Information on Status of the Species since the 2016 Status Review

The best scientific and commercial data available with respect to the adult abundance of MCR steelhead indicates a substantial downward trend in the abundance of natural-origin spawners at the DPS level from 2014 to 2019 (Figure 2.8-2). This recent downturn in adult abundance is thought to be driven primarily by marine environmental conditions and a decline in ocean productivity (see discussion below), because hydropower operations, the overall availability and quality of tributary and estuary habitat, and hatchery practices have been relatively constant or improving over the past 10 years.[280] Increased abundance of sea lions in the lower Columbia River could also be a contributing factor.

Population level estimates of natural-origin and total (natural- plus hatchery-origin) spawners through 2018 or 2019 are shown in Table 2.8-4. These data also show recent and substantial downward trends in abundance for most of the MPGs and populations (exceptions are the Klickitat and Yakima River populations) when compared to the 2009 to 2013 period (Table 2.8-4).[281] In many cases, the most recent 5-year geometric mean in natural-origin abundance is considerably below the minimum abundance thresholds established by the ICTRT (shown in Table 2.8-3). The 2019 abundance level for the Tucannon River population was lower than the most recent 5-year geomean. However, the Klickitat, Middle Fork John Day, and Umatilla River populations are well above these thresholds. A relatively limited number of hatchery fish is present on the spawning grounds within this DPS, so that the 5-year geometric means are the same or very close for both natural-origin and total estimates of adults. The 2019 natural-origin abundance level for the South Fork John Day River population was higher than the geometric mean for 2013 to 2018, but the abundance levels for the Lower John Day River Tributaries, Middle Fork John Day River, Walla Walla River, and Touchet River were lower than their respective recent geometric means.

[280] Many factors (e.g., higher summer temperatures, lower late summer flows, low spring flows, etc.) affect the ability of tributary habitat to produce juvenile migrants (capacity) each year. Recent drought and temperature patterns may have had a negative effect on tributary habitat productivity, and as a result, lower than average juvenile production may have contributed in some years to downturns in adult abundance.

[281] The upcoming status review, expected in 2021, will include population-level adult returns through 2019, and will add a new rolling 5-year geomean, for 2015 to 2019. Because the 2014 adult returns represented a recent peak at the DPS level (Figure 2.8-2), the negative percent change between the 2015–2019 and 2014–2018 geomeans will likely be greater than that shown in Table 2.8-3 between the 2014–2018 and 2009–2013 geomeans, at least for some populations.

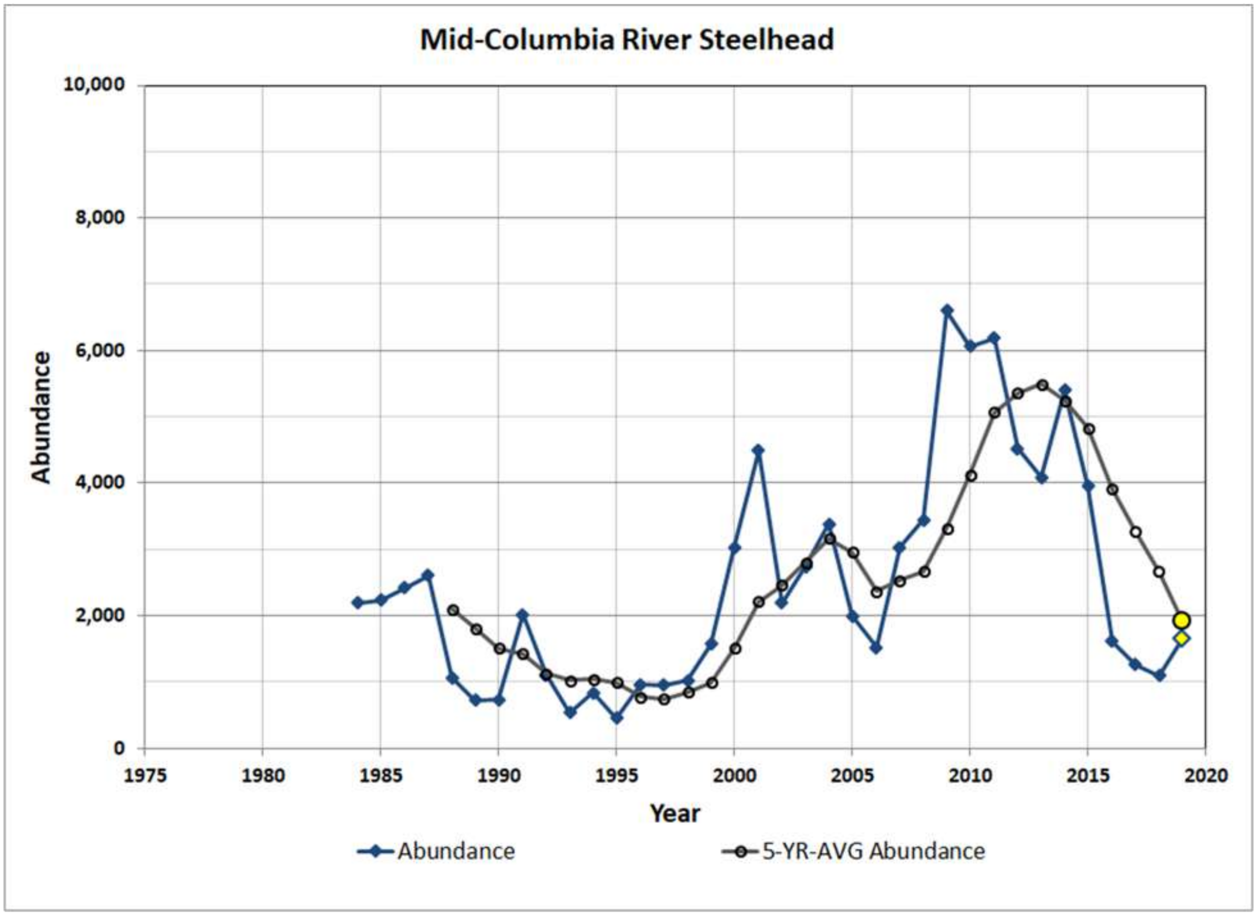

Figure 2.8-2. Annual abundance and 5-year average abundance estimates for Yakima River, natural-origin steelhead at Prosser Dam (a Major Population Group of the Mid-Columbia River Steelhead DPS) from 1984–1985 to 2018–2019. Data for year X includes passage counts occurring between July 1 of year X and June 30 of year X+1. Data for year 2019–2020 are a projection based on passage counts through December 31, 2019; average percent passage that occurs in year X; and average percent natural-origin fish. Data source: DART (2020i) -DART website's Adult Passage Query: http://www.cbr.washington.edu/dart/query/adult_graph_text

Table 2.8-4. 5-year geometric mean of natural-origin spawner counts for MCR steelhead. Number in parenthesis is the 5-year geometric mean of total spawner counts. "% change" is between the two most recent 5-year periods. "NA" means not available. At the time of drafting this opinion, 2019 data only were available for five populations. Sources: Williams 2020a, c).

Population	MPG	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
Deschutes River Eastside (summer run)	Cascade Eastern Slope Tributaries	NA	494 (1025)	3770 (4722)	1574 (2019)	944 (1104)	386 (446)	-59 (-60)	NA
Deschutes River Westside (summer run)	Cascade Eastern Slope Tributaries	293 (365)	213 (311)	662 (879)	522 (633)	656 (728)	441 (462)	-33 (-37)	NA
Fifteen Mile Creek (winter run)	Cascade Eastern Slope Tributaries	380 (380)	348 (348)	914 (914)	317 (318)	455 (470)	314 (326)	-31 (-31)	NA
Klickitat River (summer and winter run)	Cascade Eastern Slope Tributaries	NA	NA	NA	NA	1395	1629	17	NA
John Day River Lower Mainstem Tributaries (summer run)	John Day River	1635 (1645)	763 (803)	3934 (4375)	801 (1090)	2042 (2389)	1278 (1337)	-37 (-44)	1009 (1009)
John Day River Upper Mainstem Tributaries (summer run)	John Day River	995 (1000)	432 (455)	664 (722)	419 (467)	974 (1001)	559 (563)	-43 (-44)	NA
Middle Fork John Day River (summer run)	John Day River	1329 (1338)	548 (577)	1300 (1414)	478 (531)	4066 (4180)	3012 (3033)	-26 (-27)	2037 (2037)

Population	MPG	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
North Fork John Day River (summer run)	John Day River	720 (724)	1046 (1101)	2469 (2686)	1138 (1265)	3162 (3251)	1084 (1092)	-66 (-66)	NA
South Fork John Day River (summer run)	John Day River	340 (342)	186 (196)	398 (432)	412 (459)	1184 (1217)	807 (813)	-32 (-33)	1223 (1223)
Naches River (summer run)	Yakima River	318 (361)	229 (257)	701 (718)	786 (808)	1769 (1811)	1015 (1566)	-43 (-14)	NA
Satus Creek (summer run)	Yakima River	392 (444)	237 (267)	577 (592)	714 (734)	1615 (1652)	701 (1077)	-57 (-35)	NA
Toppenish Creek (summer run)	Yakima River	106 (121)	113 (127)	528 (542)	479 (493)	651 (667)	255 (378)	-61 (-43)	NA
Yakima River Upper Mainstem (summer run)	Yakima River	64 (66)	446 (47)	106 (109)	152 (154)	341 (358)	351 (502)	3 (40)	NA
Umatilla River (summer run)	Umatilla/Walla Walla Rivers	1250 (1550)	889 (1535)	2062 (2910)	1890 (2548)	3039 (3718)	2484 (2866)	-18 (-23)	NA
Walla Walla River (summer run)	Umatilla/Walla Walla Rivers	NA	587 (594)	894 (921)	662 (685)	1164 (1190)	546 (619)	-53 (-48)	281 (322)
Touchet (summer run)	Umatilla/Walla Walla Rivers	343 (388)	367 (415)	380 (407)	334 (426)	427 (560)	189 (239)	-56 (-57)	87 (139)

Although the pattern is not as clear as for other interior ESUs and DPSs, these data generally show that major population groups of MCR steelhead have increased in abundance since the 1990s, but experienced reductions during the more recent period when hydrosystem operations, the availability and quality of tributary and estuary habitat, and hatchery practices were relatively constant or improving, but ocean conditions were poor. Although these conditions (e.g., temperature and salinity, coastal food webs), appear to have been more favorable to steelhead survival and adult returns in 2018, they were still affected by recent warming trends. Increased numbers of sea lions in the lower Columbia River in the last 10 years could also be a contributing factor.

NMFS will evaluate the implications for viability risk of these more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.8-4.

2.8.1.2 Status of Critical Habitat

NMFS designated critical habitat for MCR steelhead to include all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to its confluence with the Yakima River (50 CFR 226.212(p)). All mainstem river reaches, including those in the Columbia River estuary, were given high ratings. Of 81 designated HUC5[282] watersheds in the Columbia River and the Upper Yakima, Naches, Lower Yakima, Middle Columbia/Lake Wallula, Walla Walla, Umatilla, Middle Columbia/Hood, Klickitat, Upper John Day, North Fork John Day, Middle Fork John Day, Lower John Day, Lower Deschutes, and Trout subbasins, NMFS (2005b) gave 56 a high, 22 a medium, and three a low rating for their value to the conservation (i.e., recovery) of the species.

The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features, NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b) as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. These features are essential to

[282] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watershed throughout the country. A HUC is a five-unit (5 two-digit numbers) code. Examples are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the Wenatchee River basin, Washington.

conservation because without them the species cannot successfully spawn and produce offspring.

- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.
- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.
- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case of freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The complex life cycle of MCR steelhead gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater but instead rely on limited energy stores to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005b).

In the following paragraphs, we discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary Recovery Domains.

2.8.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia Recovery Domain for MCR steelhead. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Critical habitat throughout much of the Interior Columbia Recovery Domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas. Restoration activities addressing tributary habitat quality and complexity, tributary and mainstem migration barriers, water quality, and excessive predation have improved the baseline condition for PBFs in some locations.

MCR steelhead have lost access to portions of their historical spawning and rearing habitat behind tributary dams. Construction of other large hydropower and water storage projects associated with the CRS further affected salmonid migratory conditions and survival rates. As noted above, the production of MCR steelhead was especially impacted by the development of four major Federal dams and reservoirs in the mainstem lower Columbia River migration corridor between the late 1930s and early 1970s.

Hydrosystem development also modified natural flow regimes, resulting in warmer late summer and fall water temperatures. Changes in fish communities led to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams such as turbines and juvenile bypass systems have also killed some outmigrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented improvements in the juvenile and adult migration corridors, including 24-hour volitional spill, improved surface passage routes, improved juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

Many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain are over-allocated, with more allocated water rights than existing stream flow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a limiting factor for MCR steelhead (NMFS 2009a).

Many streams in critical habitat areas for this species are listed as water-quality limited on the WDOE and ODEQ Section 303(d) Clean Water Act list for parameters such as flow, water temperatures, dissolved oxygen, chlorine, bacteria or other biological criteria (e.g., WDOE 2008). Summer stream temperature is one of the primary water quality problems for this area, with many stream reaches designated as critical habitat listed on the WDOE Clean Water Act 303(d) list for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste are common in some areas of critical habitat.

2.8.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat also has been designated for MCR steelhead in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained the dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed that restrict the position of tributary confluences.

Over time, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of the historical variability in mainstem flows in the lower river through storage and release operations at upstream reservoirs may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has reduced the delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The combined effect of these changes is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs, and thus the conservation value of critical habitat for MCR steelhead within the action area, are discussed in more detail in the Environmental Baseline section, below.

2.8.1.3 Climate Change Implications for MCR Steelhead and Critical Habitat

One factor affecting the rangewide status of MCR steelhead and aquatic habitat is climate change. The USGCRP[283] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[284] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.

[283] http://www.globalchange.gov

[284] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, earlier emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003, Crozier et al. 2008a, Martins et al. 2012, Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy among interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- Direct effects of increased water temperatures on fish physiology.
- Temperature-induced changes to stream flow patterns, which can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.
- Alterations to freshwater, estuarine, and marine food webs that alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity that affect the abundance and productivity of fish resources.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the changes vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Crozier et al. (2019) assessed MCR steelhead as having high vulnerability to the effects of climate change based on an analysis of the DPS's biological sensitivity (high), climate exposure (high), and adaptive capacity (moderate).[285] Though marine exposures were ranked high for MCR steelhead, the corresponding sensitivity of this species is poorly understood, and this was reflected in generally low data quality ranks for both marine and estuarine attributes. Linkages between adult returns and marine conditions have not been extensively evaluated for this DPS, although some inferences can be made from general ocean distribution information and temporal patterns in SAR rates.

Although detailed information on ocean distributions for MCR steelhead is not available, past studies suggest that steelhead from Pacific coastal systems generally occur in the Gulf of Alaska and subarctic waters south of the Aleutian Islands (Light et al. 1989). Abdul-Aziz et al. (2011) developed spatially explicit representations of open ocean thermal habitat for steelhead. They found that under a multimodel ensemble average of climate model outputs using the A1B emissions scenario summer habitat area declined by 36 percent for the 2080s, with the largest habitat losses in the northeast Pacific Ocean. Wintertime habitat area losses were 2 percent, with reductions at the southern end of the historical range largely offset by habitat area gains in the Bering Sea and Sea of Okhotsk.

Whether a general northward and westward displacement of the most frequently observed thermal open ocean habitat will have substantial impacts on the life-cycle, productivity, or spawning distribution of these steelhead is not known. A recent study of SAR ratios found similarities in annual marine survival patterns, with regional groupings for Puget Sound, British Columbia, and coastal Washington and Oregon (Kendall et al. 2015). These groupings suggest that for steelhead, marine/estuarine factors associated with the point of ocean entry may be a more important determinant of year class survival than general conditions in the adult ocean range.

The life stage of MCR steelhead with the highest sensitivity to climate change was the adult freshwater stage. Because many adults spend months in fresh water prior to spawning and hold during the warmest temperatures and lowest flows of the year, they may be particularly vulnerable to climate-related influences on these factors. Because of the general threat to the summer-run life history, this DPS was scored moderate in cumulative life cycle effects.

Exposure to other stressors ranked high, and for MCR steelhead, these include migration challenges from dams, especially limiting their movement upstream and downstream while over-summering and for repeating spawning. They are also vulnerable to predators and angling in thermal or flow refuges. Many of these stressors influence adults primarily, but juveniles also face habitat stress. Other stressors likely to be exacerbated in the face of climate change include widespread invasion of nonnative, warm-water species (Sanderson et al. 2009) and contaminants (Yeakley et al. 2014). Hatchery influence, both within and outside of the middle Columbia River,

[285] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results

was ranked high in reducing the resilience of steelhead in this DPS. In addition, straying of hatchery fish from populations outside of this DPS is a well-known phenomenon. This DPS is considered at lower risk than other interior steelhead (NWFSC 2015).

MCR steelhead exhibits diverse life histories. Recent work on interactions between anadromous and resident types of *O. mykiss* in the middle Columbia region and throughout the range of steelhead has shown that both types can and often do interbreed (Hard et al. 2015, Kendall et al. 2015), as is the case for many salmonids (Sloat et al. 2014). Local factors such as reproductive isolation in space or time or population sizes of either type may govern how different forms of *O. mykiss* interact. There is good evidence that resident rainbow trout can increase resilience of steelhead, as returning adults of the latter can be traced to resident parents (Kendall et al. 2015). Overall, MCR steelhead ranked moderate for adaptive capacity.

2.8.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima are likely to be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce fitness for salmonids, including MCR steelhead (Beechie et al. 2013, Wainwright and Weitkamp 2013, Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages and increased growth rates during fry stages (Crozier et al. 2008a, Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are others where it is detrimental (Sykes et al. 2009, Whitney et al. 2016).

2.8.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snowpack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and locations (Crozier et al. 2008b, Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin, in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others, it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and perhaps the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b, Beechie et al. 2013). However, river flow is already becoming more variable in many rivers and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely that this increasingly variable flow is detrimental to multiple salmon and steelhead populations in the Columbia River basin.

The effects of climate change on stream ecosystems are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes are likely to lead to shifts in the distributions of native species and facilitate the establishment of exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016, Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.8.1.3.3 Estuarine Effects

In estuarine environments, the two greatest concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013, Limburg et al. 2016). Estuaries will be affected directly by sea-level rise; as sea levels rise, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010, Wainwright and Weitkamp 2013, Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006, Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict inward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species and life history types are highly reliant on estuarine wetlands for rearing, many populations use them extensively (Jones et al. 2014). Others, such as yearling MCR steelhead, benefit from the influx of prey from the floodplain to the mainstem migration corridor (Johnson et al. 2018, PNNL and NMFS 2018, 2020).

2.8.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010, Asch 2015, Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years. For example, range extensions were documented in many species from southern California to Alaska during the unusually warm water associated with the marine heatwave known as "the blob" in 2014 and 2015 (Bond et al. 2015, Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002, Fisher et al. 2015). The potential for MCR steelhead to shift their distribution north was discussed above. The frequency of extreme conditions such as those associated with marine heatwaves or El Niño events is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015, Rehage and Blanchard 2016). While it is certain that these effects will occur, current models cannot predict the composition or outcomes of future trophic interactions. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm ocean conditions, suggesting that, at a minimum, prey availability and prey quality, "bottom-up" drivers of growth and survival, may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009, Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014, Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unaffected by climate change, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean (Tomaro et al. 2012), and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska, and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007, Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in Alaska salmon productivity and survival (Mantua et al. 1997, Martins et al. 2012). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009, Martins et al. 2012). However, more recent information indicates that Alaska salmon, which have historically contrasted with southern populations by benefitting from warm phases of the PDO, no longer have a positive correlation with winter sea-surface temperature (Litzow et al. 2018) and are more synchronized with southern populations (Ohlberger et al. 2016). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon is likely to be its influence on marine food webs, especially at the lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015, Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.8.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change in general, including in the Pacific Northwest. The indirect effects of climate change are also uncertain, including whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013, Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will involve impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning that some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycles. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is less certain, leading to a range of potential future outcomes.

2.8.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For MCR steelhead, we focus our description of the environmental baseline on where MCR steelhead juveniles and adults are most exposed to the effects of the proposed action. We also consider the broader action area, including tributary habitat, because the Action Agencies may conduct habitat restoration actions and because these areas provide an important context for understanding the effects of the proposed action. The area of greatest exposure to the effects of the proposed action is the Columbia River from the mouth and plume[286] up to Priest Rapids Dam with respect to actions that affect flow. The area includes tributaries and their confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions in the Columbia River basin.

In addition, recent information indicates a portion of returning MCR steelhead adults migrate into the Snake River, presumably to find thermal refugia during summer months (Keefer and Caudill 2017). This includes all the lower sections of tributaries that have been inundated by reservoir water as a result of the operation of the CRS. Therefore, the area in which MCR steelhead are exposed to the effects of the proposed action also includes Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Reservoirs.

2.8.2.1 Mainstem Habitat

Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water-management operations, the construction and operation of mainstem hydroelectric projects, the introduction of nonnative species (e.g., smallmouth bass, walleye, channel catfish, invertebrates, etc.), and other human activities that have degraded water quality and habitat.

2.8.2.1.1 Seasonal Flows

On the mainstem of the Snake and Columbia Rivers, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events

[286] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

(Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.8-3). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

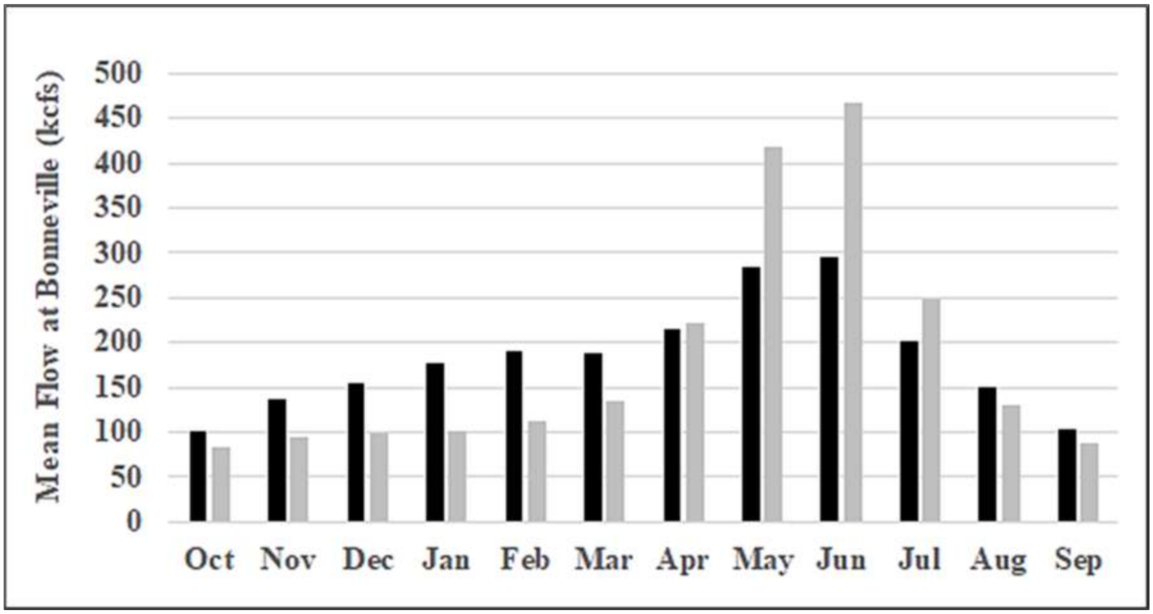

Figure 2.8-3. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[287] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount

[287] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

of runoff expected in a given year (Table 2.8-5). This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Most MCR steelhead smolts migrate to sea during the spring months. Reduced spring and summer flows have increased travel times during outmigration for MCR steelhead and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

Table 2.8-5. Seasonal flow objectives and planning dates for the mainstem Columbia and Lower Snake Rivers. NA indicates that there is not a flow objective for the season at these projects.

Location	Spring		Summer	
	Dates	Objective (kcfs)	Dates	Objective (kcfs)
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100[a]	6/21 to 8/31	50 to 55[a]
Columbia River at McNary Dam	4/10 to 6/30	220 to 260[a]	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 to 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160[b]	NA	NA

[a] Objective varies based on actual and forecasted water conditions.

[b] Objective varies according to water volume forecasts and is for chum salmon (spawning period is approximately November 1 through December and protection flow objectives are based on redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

Seasonal flow objectives for improving the migration and survival of spring and summer juvenile migrants are based on water supply forecasts; however, mean seasonal flows in the past did not always achieve the flow objectives when measured as a seasonal average flow. From 1998 to 2019, seasonal spring flow objectives were met or exceeded during 81 percent of years at McNary Dam and during 48 percent of years at Lower Granite Dam. For the years when the spring flow objectives were not met, the average seasonal flow was 88 percent of the spring flow objective at McNary Dam and 78 percent of the spring flow objective at Lower Granite Dam. Across all years, the average percentage of the spring flow objective obtained was 113 percent at McNary Dam and 101 percent at Lower Granite Dam. Achieving these seasonal flow objectives provides multiple benefits for smolts in the migration corridor, estuary, and plume. Higher spring flow helps reduce fish travel time, increases juvenile access to shallow water habitat along the river banks, increases the flux of invertebrate prey to shoreline habitat, increases turbidity (which can reduce predation on juvenile migrants), and increases the size of the Columbia River plume, which is a key transition corridor for smolts to the nearshore ocean environment. Conversely, when seasonal flow objectives are not met, juvenile survival may be reduced via these same pathways of ecological effects.

From 1998 to 2019, summer flow objectives were met or exceeded during 14 percent of years at McNary Dam and during 18 percent of years at Lower Granite Dam. For the years when the summer flow objectives were not met, the average seasonal flow was 74 percent of the summer flow objective at McNary Dam and 66 percent of the summer flow objective at Lower Granite Dam. Across all years, the average percentage of the summer flow objective obtained was 85 percent at McNary Dam and 79 percent at Lower Granite Dam. The benefits provided by attaining summer flow objectives, and potential impacts associated with not meeting them, are the same as those previously described for the spring flow objectives.

Recommendations on when to manage flows for the benefit of juvenile passage are made by the TMT during the juvenile migration season. These recommendations are informed by the status of the juvenile migration, water supply forecasts, river flow conditions, and river flow forecasts during the juvenile migration season.

2.8.2.1.2 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult MCR steelhead is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017i). Together, these contaminants are likely affecting the productivity and abundance of MCR steelhead, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead is a concern; because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington for temperature standard exceedances. Temperature conditions in the Columbia River basin are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges such as cities and industries.
- Climate change.

Temperatures in the middle Columbia River are affected by Grand Coulee Dam, completed in 1942. Thermal inertia from the large mass of water in the reservoir (total storage capacity of 9.6 million acre-feet, active capacity of about 5.2 million acre-feet) results in delayed warming in the spring (cooler temperatures) and delayed cooling in the late summer and fall (warmer temperatures). Even in the extremely warm year of 2015, the average temperature of Grand Coulee outflows was less than 68°F (Figure 2.8-4) (NMFS 2016g), indicating little risk from this environmental parameter to spring migrating MCR steelhead smolts. However, warmer August and September temperatures, though not exceeding the State of Washington's temperature standard, would increase the risk of negative effects, such as pre-spawning mortality and reduced gamete viability, to the adults that are migrating in the summer.

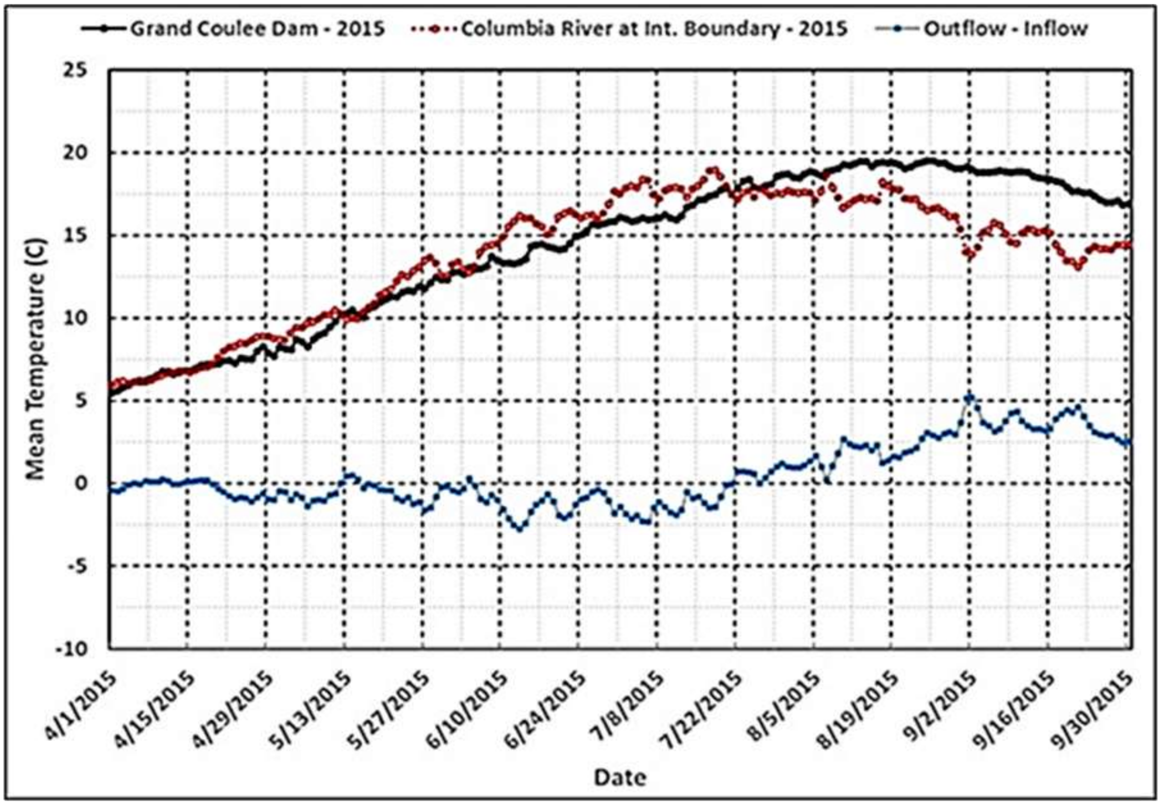

Figure 2.8-4. Outflow temperatures at Grand Coulee Dam compared to upstream Columbia River temperatures at the international boundary. Blue line indicates the difference (inflow – outflow) in temperature. Source: BOR Hydromet Data.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period from 1960 to 1995, Perkins and Richmond (2001) compared water temperature records in the Columbia River basin and found three notable differences between the current versus an unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the middle and lower reaches of the Columbia River likely have similar effects.

These hydrosystem effects (which stem from both upstream storage projects and run-of-river mainstem projects) continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broadscale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and at temperature extremes, survival.

The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the middle and lower Columbia River during spring. Exposure to elevated temperatures in the lower Columbia River from its mouth to its confluence with the Snake River, is greatest for adult MCR steelhead migrating in the late summer when water temperatures are highest (Keefer et al. 2016, Keefer and Caudill 2017).

Low flows and high summer temperatures in tributary habitats can effectively create temporary migration barriers that reduce habitat access until conditions improve. These impacts to water quality in tributary habitat can affect the run timing and survival on the way to natal spawning areas for adult MCR steelhead. Based on PIT tags and radio-telemetry research, a substantial portion of returning MCR steelhead temporarily reject or overshoot[288] their natal tributaries during the summer migration due to high temperature and/or low tributary flow, and they seek thermal refuge in McNary or the lower Snake River reservoirs (Keefer et al. 2016). Some of these fish fall back over or through the dam, when fish passage protection is available, and return to their natal stream successfully. However, other fish attempt to pass the dams after fish protections have ended (juvenile fish passage spill ends in August, juvenile bypass systems close mid-November), and migrate through turbine units—typically the lowest-survival route for adult steelhead (Colotelo et al. 2014, Normandeau 2014).

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with Federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect water quality and mainstem habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995a). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam, except The Dalles Dam. The FERC-licensed Wanapum Dam in the middle Columbia

[288] Tributary overshoot occurs when adult salmonids homing to natal sites continue upstream past the mouth of their natal stream.

River reach also uses these structures to control TDG. Biological monitoring shows that the incidence of observable GBT symptoms in both migrating smolts and adults is between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[289] Under recent operations (2008 to 2019), exposure to elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June, affecting most UCR steelhead smolts. Monitoring data from 1998 to 2018 indicate that TDG did not increase instantaneous mortality rates for juvenile steelhead in the CRS (CSS 2019).

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

Sediment Transport

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and

[289] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.8.2.1.3 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of SR spring/summer Chinook salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[290] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted “losses” of oil or grease are tracked.

[290] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[291] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters which are or may be discharged at a level which "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling

[291] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river.

water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.8.2.1.3 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adults that are migrating past the dams or overwintering within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Few juvenile MCR steelhead have been affected by these activities, because they predominantly migrate from April to June.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult MCR steelhead has likely resulted in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes have minimized the impacts.

2.8.2.1.4 Adult Migration/Survival

Under typical conditions, after accounting for harvest, adult MCR steelhead typically have relatively high survival through dams and reservoirs within the CRS (Keefer et al. 2016). The primary factors contributing to safe, timely, and effective adult upstream passage through CRS dams are tailrace flow dynamics, sufficient attraction flows to fish ladder entrances, operating ladders within established operating criteria (Fish Passage Plan), reducing fallback,[292] and maintaining safe ladder temperature and differentials. The 5-year average (2014 to 2018) was 96.4 percent survival from Bonneville to McNary Dam (based on fish originating from the Yakima and Walla Walla Rivers) (Figure 2.8-5).

[292] Fallback is the proportion of adult migrants that successfully migrate over a dam and subsequently migrate downstream of the dam.

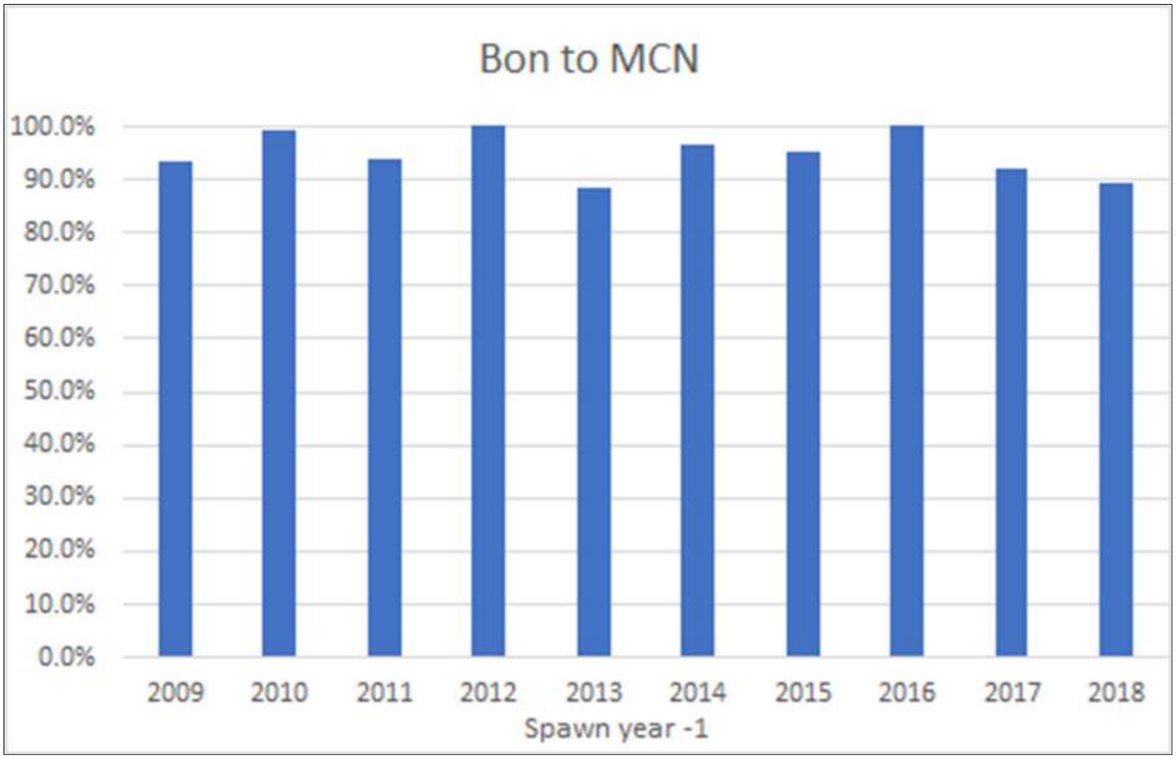

Figure 2.8-5. Bonneville to McNary Dam survival estimates for Middle Columbia Steelhead originating from the Yakima and Walla Walla rivers corrected for harvest and straying.

The survival rates of populations that do not pass McNary Dam can be estimated by applying a per dam survival rate of the Bonneville to McNary survival rate. This gives an estimate of 98.7 percent survival for MCR steelhead that enter the CRS in The Dalles Reservoir, and 97.5 percent for those that enter the CRS in John Day Reservoir. These estimates were corrected for losses due to harvest and straying. Absolute estimates (including all sources of mortality) can be directly estimated for the Bonneville to Dalles and Dalles to McNary reaches after a PIT tag detector was installed at The Dalles in 2013. Another detector came on line at John Day in 2017 allowing direct estimates of absolute survival in all three reaches of the Lower Columbia River (Table 2.8-6)

Table 2.8-6. Absolute (all sources of mortality including straying and harvest) estimates of survival for Middle Columbia Steelhead by reach in the lower Columbia River. Cells with gray indicate estimates from larger reaches using the nth root of the observed survival.

	Reach Survival Estimate			
	Bon to TDA	**TDA to JDA**	**JDA to MCN**	**Bon to MCN**
2009	92.0%	92.0%	92.0%	78.0%
2010	94.0%	94.0%	94.0%	83.0%
2011	93.0%	93.0%	93.0%	80.4%
2012	94.1%	94.1%	94.1%	83.4%

	Reach Survival Estimate			
	Bon to TDA	**TDA to JDA**	**JDA to MCN**	**Bon to MCN**
2013	82.4%	93.8%	93.8%	72.5%
2014	84.7%	97.4%	97.4%	80.4%
2015	83.7%	96.6%	96.6%	78.2%
2016	88.2%	94.8%	94.8%	79.3%
2017	90.8%	94.4%	94.4%	80.9%
2018	83.7%	91.4%	101.7%	77.8%

Each year, when the mainstem Columbia River temperature increases to above 64.4°F in the summer months, a large portion of MCR steelhead (and other steelhead DPSs) locate thermal refugia in cool tributaries such as the Little White Salmon, White Salmon, or Deschutes Rivers, or in deeper/ cooler mainstem areas within the CRS. Sections of the Snake River also provide thermal refugia for a portion of MCR steelhead with the operation of deep withdrawals from Dworshak Dam (Keefer et al. 2016). Because of the cold-water withdrawals, the Snake River, from the confluence of the Clearwater River to Little Goose Dam, is thermally stratified in the summer months, providing cool water at depth with sufficient thermal refugia capacity for adult steelhead. Based on PIT detections, in the last 5 years, an average of 12.3 percent and 4.4 percent of the PIT-tagged MCR steelhead that passed Bonneville Dam also passed Ice Harbor and Lower Granite Dams, respectively (Table 2.8-7). This is evidence of tributary overshoot, Steelhead which overshoot their natal tributaries must return downstream to spawn. If this downstream movement includes passing a dam, adults are at higher risk of injury or mortality if safe passage routes such as spill are not available. A significant number of fish pass downstream after the regular spill season (Keefer et al. 2015).

Table 2.8-7. Counts and percentage of PIT-tagged adult MCR steelhead (hatchery and natural-origin combined) detected at Bonneville Dam (BON) and subsequently detected at a Snake River dam equipped with adult PIT detection in the fish ladder: Ice Harbor Dam (IHR), Lower Monumental Dam (LGS) and Lower Granite Dam (LGR) Note: Any adult detected in a Snake River dam must swim back over the dam to return to spawn in MCR steelhead spawning habitat. There was no PIT tag detection (no data or ND - grey shaded cells) at LMN or LGS before 2014.

Date	BON	IHR	%	LMN	%	LGS	%	LGR	%
2017	384	55	14.3%	44	11.5%	26	6.8%	23	6.0%
2016	408	69	16.9%	44	10.8%	38	9.3%	28	6.9%
2015	805	128	15.9%	98	12.2%	66	8.2%	41	5.1%
2014	771	86	11.2%	55	7.1%	40	5.2%	28	3.6%
2013	685	38	5.5%	ND	ND	ND	ND	13	1.9%
2012	534	49	9.2%	ND	ND	ND	ND	18	3.4%
2011	821	80	9.7%	ND	ND	ND	ND	38	4.6%
2010	644	103	16.0%	ND	ND	ND	ND	41	6.4%
2009	704	115	16.3%	ND	ND	ND	ND	50	7.1%

Date	BON	IHR	%	LMN	%	LGS	%	LGR	%
2008	439	75	17.1%	ND	ND	ND	ND	25	5.7%
5-Year Avg	611	75	12.3%	60	9.9%	43	7.0%	27	4.4%
10-Year Avg	620	80	12.8%			NA	NA	31	4.9%

During the peak of the MCR steelhead adult migration in July and August, solar radiation heats reservoir surface waters (Table 2.8-8), which can lead to high temperatures and temperature differentials between the bottom and top sections in a fish ladder. Ladder temperatures exceeding 68°F and differentials greater than 1.8°F have been demonstrated to delay passage for steelhead and Chinook salmon at the CRS dams in the Lower Snake River (Caudill et al. 2013). As temperature differentials increase, time required for passage increases; a temperature differential of 5.4°F increased the ladder passage time for steelhead at Lower Granite Dam by a factor of 2.4 to 2.5 compared to no temperature differential. Caudill et al. 2013 noted that the increased travel time, increased thermal exposure, and related physiological stresses could reduce successful migration to natal tributaries. Ladder temperatures commonly exceed 68°F, and ladder differentials regularly exceed 1.8°F while MCR steelhead are migrating (McCann 2018). During the most extreme summer days, ladder temperatures in CRS dams can exceed 75.0°F, and ladder differentials can exceed 4.5°F (FPC 2019). Fish ladder–cooling structures have been installed at Little Goose and Lower Granite Dams that pump colder water from deeper in the reservoir into the fish ladder to reduce ladder temperature differentials. There are currently no structures to reduce ladder temperatures at the other CRS dams, but research has identified that during the warmest months, cooler water is available that could be pumped into ladder exits to reduce high temperatures and ladder differentials (Lundell 2019).

Table 2.8-8. Typical August temperature measured in the forebay of McNary Dam in 2017 in degrees Fahrenheit at various depths, indicating solar radiation inputs differentially impacting the water surface. Note that the top (0.5-m) depths are much warmer than the bottom (21m), especially in the peak of the afternoon. http://pweb.crohms.org/ftppub/water_quality/tempstrings/MCN_S1_2017_08.html

Date	Time	0.5m	1.5m	3m	5m	10m	15m	20m	21m
08/09/2017	00:00	74.6	74.0	72.7	71.3	70.6	70.5	70.5	70.5
	01:00	74.9	74.8	73.0	72.6	70.6	70.5	70.5	70.5
	02:00	75.7	75.0	73.2	71.6	70.6	70.5	70.5	70.5
	03:00	75.0	74.6	72.8	71.3	70.6	70.5	70.5	70.5
	04:00	74.9	74.7	72.6	71.3	70.6	70.5	70.5	70.5
	05:00	74.5	73.7	72.5	71.3	70.6	70.5	70.5	70.5
	06:00	74.4	72.7	72.2	71.3	70.6	70.5	70.5	70.5
	07:00	73.9	73.0	71.8	71.3	70.6	70.5	70.5	70.5
	08:00	73.9	73.3	72.2	71.6	70.6	70.5	70.5	70.4
	09:00	74.2	73.1	71.8	71.0	70.6	70.4	70.5	70.4
	10:00	74.9	73.2	72.1	70.8	70.5	70.4	70.4	70.4
	11:00	74.2	73.0	72.1	70.6	70.5	70.4	70.4	70.4

Date	Time	0.5m	1.5m	3m	5m	10m	15m	20m	21m
	12:00	73.8	73.1	72.2	70.7	70.5	70.4	70.4	70.4
	13:00	76.2	73.5	72.6	71.9	70.5	70.4	70.4	70.4
	14:00	76.9	75.5	72.8	71.5	70.4	70.4	70.4	70.3
	15:00	80.1	75.2	72.7	71.6	70.4	70.4	70.4	70.4
	16:00	78.4	74.4	73.1	71.9	70.4	70.4	70.4	70.4
	17:00	78.9	74.4	72.8	71.2	70.4	70.4	70.4	70.4
	18:00	78.0	74.4	72.8	71.1	70.4	70.4	70.4	70.4
	19:00	76.9	76.3	72.6	71.2	70.4	70.4	70.4	70.4
	20:00	75.5	75.5	72.7	71.4	70.4	70.3	70.4	70.3
	21:00	76.4	74.9	73.2	71.8	70.4	70.3	70.3	70.3
	22:00	76.9	74.9	73.6	71.7	70.4	70.3	70.3	70.3
	23:00	77.5	74.8	72.7	71.0	70.4	70.3	70.3	70.3

A large proportion of MCR steelhead from the John Day MPG do not enter the John Day River in the summer, likely because of elevated water temperatures. Based on PIT detections, a large group of these fish migrate past the John Day River in the summer and overshoot McNary Dam, presumably to find cooler water refuge until the John Day River cools. Many of these do not attempt to migrate back downstream through McNary Dam until after the prescribed spill has ended in August, and a smaller portion do not attempt downstream migration until after the juvenile bypass system has shut down in mid-November. This leaves the turbines as the only available passage route for many of the fish, which is the lowest survival route for adult steelhead. Research conducted since the implementation of the 2008 biological opinion has demonstrated the spillway weir is the most effective and safe route to pass adult steelhead at McNary Dam. Normandeau et al. (2014) conducted an adult steelhead balloon tagging study at McNary Dam and found that 98.0 percent of the steelhead passing the Temporary Spillway Weir (TSW) survived and were injury-free. The fish passed through the turbine unit had significantly lower survival rates (91 percent) and more life-threatening injuries, presumably caused by blade strike and shear forces. Colotelo et al. (2013) also found that the survival rate of adult steelhead kelts through spillways and surface weirs was high (>95 percent) and survival through turbine units was lowest (<80 percent), indicating that overshoots survive at a higher rate when spill protection is provided when they migrate back downstream.

Keefer and his colleagues (2007) found that winter fallback-related mortality is almost certainly not distributed evenly among populations, and overshoot-related winter fallback mortality may be relatively high at dams closest to home tributaries, such as for Deschutes River fish at John Day Dam or John Day River fish at McNary Dam. Keefer et al. (2007) found that fallbacks in March and November have the largest negative effect on survival and The Dalles Dam had the largest negative effect on survival across the winter months of the study.

CRS-related mortality of downstream migrating kelts is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 40.2 and 44.8 percent of Snake River steelhead kelts survived from the Lower Granite forebay to the lower Columbia River (RM156) and the Bonneville dam face (RM 234), respectively, and only 60.4 and 67.3 percent survived from the McNary forebay to the Lower Columbia River (RM156) and Bonneville dam face, respectively. It is important to note that in this study, only fair and good condition kelts were selected for tagging, and these survival rates cannot be applied to poor condition kelts. Based on this limited information, up to 40 percent of MCR kelts arriving at McNary Dam (less for MCR kelts entering the mainstem Columbia River in the John Day, The Dalles, or Bonneville Reservoirs) are lost upstream of Bonneville Dam.

2.8.2.1.5 Juvenile Migration/Survival

All populations of the MCR steelhead DPS are affected by juvenile passage conditions through at least one mainstem dam and reservoir. Populations originating from the Yakima and Walla Walla Rivers must migrate through four mainstem dams and reservoirs, those originating from the John Day and Umatilla basins migrate through three mainstem dams and reservoirs, and populations from the Cascades Eastern Slope Tributaries MPG pass one to two dams, depending on stream of origin.

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and nonnative species that are predators, competitors, or food sources for migrating juvenile steelhead. The travel times of migrating smolts are increased through the reservoirs, increasing exposure to both native and nonnative predators (see Section 2.7.2.6), and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spill bays, or surface passage routes) (NMFS 2008a, b).

Table 2.8-9 depicts the Fish Operations Plan (FOP) for spring spill during 2017, 2018, 2019, and 2020 at the Action Agency-operated dams in the lower Columbia River. There was a substantial increase in spill over the dam spillways in the spring during 2018 in response to a court order requiring additional spill. Spill levels in 2019 and 2020 using flexible spill, as proposed by the Action Agencies and consulted upon in the 2019 CRS biological opinion, were also higher than spill in 2017 at most projects.

Table 2.8-9. Summary of 2017, 2018, 2019, and 2020 Fish Operations Plan spring spill levels (April 10 to June 15) at lower Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)[1]	2018 Operations	2019 Flex Spill	2020 Flex Spill
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)	125% TDG gas cap (16 hours per day) / 48% Performance Standard (8 hours per day)
John Day	**April 10–April 28:** 30%/30% **April 28–June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)	120% TDG gas cap (16 hours per day) / 32% Performance Standard (8 hours per day)
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay	120% TDG gas cap (16 hours per day) / 40% Performance Standard (8 hours per day)	40%/40%
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)	120% TDG gas cap up to 150 kcfs (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)	125% TDG gas cap up to 150 kcfs (16 hours per day) / 100 kcfs Performance Standard (8 hours per day)

[1] Spill operations are described as percent of project outflow or kcfs.

As a result of successful implementation of RPAs in the 2008 biological opinion, extensive structural and operational improvements have been made at the four lower Columbia River dams to improve survival for spring migrants. All four lower Columbia River CRS projects have well-functioning surface passage modifications in addition to 24-hour spring and summer spill programs to facilitate faster juvenile passage and higher survival. The surface passage modifications at the dams provide the highest survival routes available for juvenile steelhead, and their influence on improving spill passage efficiency and reducing forebay delay is clearly established. A series of performance tests that occurred as a result of the 2008 biological opinion indicated that average juvenile steelhead survival through each of the four lower Columbia River dams typically exceed the survival target of 96.0 percent survival per dam (Fredricks 2017). Juvenile fish transportation efforts ceased at McNary Dam after 2012 due to high cost and limited observed SAR benefit following initiation of the 24-hour spring spill program and operation of the fish survival and passage modifications.

While dam passage survival has improved and is relatively high for steelhead in recent years, estimated survival of juvenile steelhead through these same reservoirs is typically lower and the data are variable. Zabel (2019) and Widener et al. (2020) calculated survival from John Day to Bonneville Dam for hatchery and natural-origin steelhead combined (including Snake River and Upper Columbia populations) and reports that survival increased between 2007 and 2013 from 58 percent to nearly 100 percent. However, survival subsequently decreased from 2013 to 2017 to 64.3 percent. In 2017, survival from McNary to Bonneville Dam for hatchery and natural-origin steelhead combined was 60.5 percent. Estimates from a 2018 reach survival active tag study indicated that 78 percent of steelhead survived from McNary to Bonneville Dam during gas cap spill (Harnish et al. 2018). Widener et al. (2020) reports that John Day to Bonneville survival for hatchery and natural-origin surrogate Snake River steelhead varies substantially, but has averaged 80.0 percent over the last 20 years.

It is unclear what is causing the variable trends in reach survival, but they may be due to variability in sampling precision, river flows, spill percentages, bypass debris, fish condition, and/or predation factors. One important note about these survival estimates is that they are based on PIT-tag detection systems that are located in the juvenile bypass systems. Using bypass PIT detections as a surrogate for spillway past fish could add additional bias to the data since higher debris loads and/or TDG may be differentially impacting fish in the shallow-water environment. Descaling and mortality rates tend to increase when flows increase in the CRS, as debris loads increase on the trashracks with the higher flows. It has also been hypothesized that fish with weaker swimming capabilities and a lower chance of survival are more likely to pass through the juvenile bypass systems than via spill, which could mean that these survival estimates at the dams may be biased and underestimate survival because they are largely based on fish that have a lower chance of survival than the general population (Zabel et al. 2005, Faulkner et al. 2019).

2.8.2.1.6 Transportation

Juvenile fish transport has been used for mitigation in the CRS since 1981 (Baxter et al. 1996). At dams with juvenile bypass systems, turbine intake screens divert smolts away from turbine units and into a system of channels and flumes.[293] At dams with transportation facilities, diverted fish may be bypassed into the tailrace below the dam or collected in raceways, where they can be loaded onto barges or trucks, transported below Bonneville Dam, and then released into the lower Columbia River to continue migrating to the ocean. The only dams in the CRS currently used for collection are Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam in the lower Snake River. A few late-migrating MCR steelhead were transported from McNary Dam from 1985 to 2012, after which all transport from McNary Dam ceased based on a recommendation from NMFS.

2.8.2.2 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways: competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-

[293]All of the powerhouses at the four lower Columbia River mainstem dams have juvenile bypass systems, with the exception of The Dalles Dam and Bonneville Dam, Powerhouse 1; Rocky Reach Dam is the only mid-Columbia PUD project which has a conventional screening system on some of its turbine units.

influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Out-of-DPS hatchery strays may pose a risk to some Oregon MCR steelhead populations, particularly the Eastside and Westside Deschutes and John Day populations. An assessment by Keefer et al. (2016) identified that a significant proportion of spawners in the Deschutes River and John Day River populations were out-of-DPS strays. However, they also noted that some out-of-basin steelhead migrating into the Deschutes River appeared to be seeking thermal refugia and eventually returned to their natal streams (Keefer et al. 2016). NMFS' most recent status review noted a decrease in the proportion of strays in the John Day River basin and identified a need for additional information to assess the effects of hatchery strays on natural production in the Deschutes River and John Day River systems (NMFS 2016g).

Genetic sampling has documented that the Rock Creek steelhead population is highly introgressed with the SRB steelhead DPS (85 percent of adult PIT-tag detections with known juvenile origin were of Snake River origin). With additional data, it should become apparent if steelhead in Rock Creek are a viable naturalized subpopulation or are sustained by an annual influx of stray steelhead originating from the Snake River (NWFSC 2015, Conley 2015). Snake River steelhead transport rates have decreased as a result of earlier migrations and higher spill, and transported SRB steelhead are known to stray at higher rates than fish that migrated inriver as juveniles.

Hatchery programs operated in middle Columbia tributaries—including the Umatilla, Walla Walla, and Westside Deschutes River subbasins—also create some risks due to ecological interactions, and genetic introgression. For hatchery programs that incorporate sufficient natural-origin adults into the broodstock or were derived from the endemic population, NMFS has determined that fish produced therein have not changed substantially or displayed a level of genetic divergence from the local population that is greater than the divergence among closely related natural populations within the DPS (Jones 2015). The Umatilla River summer steelhead and the Touchet River endemic summer steelhead (Walla Walla Basin) programs currently incorporate natural-origin adults into the broodstock (NMFS 2019e), and the Round Butte Hatchery summer steelhead program (Deschutes River) is proposing to incorporate natural-origin adults into the broodstock and is currently in ESA Section 7 consultation.

Collections for the Yakima River Kelt Reconditioning Program are made at the Chandler Juvenile Monitoring Facility, where approximately 20 percent of the outmigrating, post-spawn steelhead are collected in the spring and then transported to Prosser Hatchery for reconditioning using the methods described by Trammell et al. (2016). After 6 months, the consecutive spawners are released both above and below Prosser Dam when the upper Columbia River steelhead run is returning from the ocean. The reconditioned and released fish proceed to over-winter locations with the rest of the Yakima River populations, and to spawning grounds in the spring (Hatch et al. 2018). From 2000 to 2017 the number of kelt steelhead collected by the Yakima River Program has ranged from 118 to 1,157 fish per year. Of these fish, at least 22 percent and up to 76 percent have been successfully reconditioned and released. (The largest number of fish released was 404 in 2010.) Since 2009, estradiol levels have been measured in the female kelts to determine whether they will be ready to spawn in the spring. The number of known mature females released by the program as consecutive spawners has ranged between 56 and 382 per year from 2009 to 2017, with an average of 175 per year. Since 2013, the program has retained females with low estradiol levels for an additional year of reconditioning. This method has successfully added an additional 8 to 37 (19 on average) “skip spawner” female kelts to the annual releases (Hatch 2018).

NMFS has consulted on all the steelhead hatchery programs in the middle Columbia River basin, with the exception of the Round Butte summer steelhead hatchery program, for which a consultation is in progress. In all the completed consultations NMFS has concluded that the programs undergoing consultation are not likely to appreciably reduce the likelihood of survival and recovery of the MCR steelhead listed DPS (NMFS 2019e).

2.8.2.3 Recent Ocean and Columbia River Harvest

Incidental catches of steelhead in ocean fisheries targeting other species are low (hundreds of fish each year or less) (PFMC 2019), and retention of steelhead in non-treaty fisheries is currently prohibited. NMFS concluded that it is not necessary to implement ocean fishery management actions to minimize impacts to steelhead beyond those already in place (Thom 2019). While the general principles for quantifying treaty fishing rights are well established, their application to individual runs during the annual fishing seasons is complicated. Annual calculations of allowable harvest rates depend on (among other things) estimated run sizes for the particular year, the mix of stocks that is present, application of the ESA to mixed-stock fisheries, application of the tenets of the “conservation necessity principle” for treaty Indian fisheries, and the effect of both the ESA and the conservation necessity principle on treaty and non-treaty allocations. While the precise quantification of treaty Indian fishing rights during a particular fishing season often cannot be established by a rigid formula, the treaty fishing right itself continues to exist and must be accounted for in the environmental baseline.

NMFS recently signed the 2018 to 2027 *U.S. v. Oregon* Management Agreement for the Columbia River basin. That decision was based on both the Final EIS and the associated biological opinion (NMFS 2018a). This agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho, and ensures fair sharing of harvestable fish between tribal and nontribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*. The agreement includes harvest rate limits on Columbia River basin fisheries impacting MCR steelhead, and these harvest limits continue to be annually managed by the fisheries co-managers. The 2018 to 2027 *U.S. v. Oregon* Management Agreement allows 4 percent harvest, but 10 percent mortality of natural-origin, released summer-run MCR steelhead and 2 percent mortality of natural-origin, released winter-run fish. Average take of MCR steelhead since 2008 has been 1.9 percent, ranging from 1.1 to 3.3 percent per year (NMFS 2018a).

Steelhead presmolts can be encountered in recreational trout fisheries and adults can be encountered in commercial, recreational, and tribal fisheries on the mainstem Columbia River and its tributaries. However, given current management regulations for mainstem Columbia River and tributary fisheries, harvest is not considered a primary or secondary threat due to the low impact on viability.

2.8.2.4 Tributary Habitat

Nearly all historical habitat for the MCR steelhead DPS has been modified extensively by human activities. Many habitat improvement actions have been implemented that benefit the targeted populations, and those benefits will continue to accrue over time as the habitats mature. In addition, land use practices and regulatory mechanisms have improved from historical practices and regulations (Carmichael and Taylor 2010; NMFS 2009a, 2016g). As a result, in some places, habitat conditions for this DPS are likely improving (Carmichael and Taylor 2010, NMFS 2016g). Overall, however, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of MCR steelhead (NMFS 2009a, 2016g). In addition, ongoing development and land-use activities may continue to have negative effects.

Generally, the ability of tributary habitats in the middle Columbia River to support the viability of this DPS is limited by one or more of the following factors: 1) impaired fish passage (including tributary dams), 2) reduced stream complexity and channel structure, 3) excess fine sediment, 4) elevated summer water temperature, 5) diminished stream flow during critical periods, 6) reduced floodplain connectivity and function, and 7) degraded riparian condition. Human activities that have contributed to these limiting factors include agricultural development, livestock grazing, forest management, urbanization, gravel mining, beaver removal, construction of tributary dams, and withdrawals of water for irrigation and human consumption. While some streams and stream reaches retain highly functional habitat, human activities—particularly agricultural activities—have had a large and widespread impact on steelhead habitat quality and quantity across the DPS and have degraded spawning and rearing habitat conditions (NMFS 2009a).

Since the ESA listings, and in some cases before, habitat restoration efforts have been implemented throughout the middle Columbia River basin. These efforts have been funded and implemented by the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies (NMFS 2009a, 2014a, 2016g).

Examples of recent tributary habitat improvement actions in this DPS include:

- Cascades Eastern Slope Tributaries MPG: Improved passage and operating procedures at the Pelton Round Butte Dam Project to improve water quality; improvements to other tributary barriers to open previously inaccessible habitat; improvements to stream channel complexity to improve rearing habitat; riparian area restoration and protection to improve water temperatures; restoration of side channels to improve rearing habitat; irrigation system improvements to provide greater efficiency and protect and restore stream flow; restoration and reconnection of floodplains to improve rearing habitat; acquisition of development rights to protect habitat; and agreements among landowners to reduce stream temperatures through appropriate water use. Condit Dam was fully removed in 2012, restoring full passage to historical habitat on the White Salmon River. PacifiCorp restored much of the new bank line in the former reservoir area to its original contours and conducted extensive planting with native grasses, shrubs, and trees. Engineered log jams were installed at various locations to reduce erosion. This has increased the amount of tributary habitat available to the Cascades Eastern Slope Tributaries MPG (NMFS 2016g).

- John Day River MPG: Between 2010 and 2013, within the lower John Day River watershed, 3,829 acres were acquired to protect habitat, 38 barriers were removed (making an additional 293 stream miles accessible), 40 fish diversions were screened, 44 stream miles were treated to improve habitat complexity, 3,955 acres of riparian habitat were treated or protected, 12 irrigation systems were improved, and 243 water/sediment control structures were installed (NMFS 2016g).
- Umatilla and Walla Walla River MPG: Improvements include instream flow protection, irrigation systems improvements for greater efficiency, improvements to barriers to provide access to previously inaccessible habitat, and screening of irrigation (NMFS 2016g).
- Yakima River MPG: The Yakima Basin Integrated Plan was completed by Reclamation and Washington State Department of Ecology in 2012. This $4 billion, 30-year multi-stakeholder effort is focused on improving fish habitat while also meeting the water demands of Washington's agricultural industry, and will benefit MCR steelhead. Other improvements include levee removals and setbacks to allow more channel migration and create off-channel habitat, restoration of flows, removal of passage barriers, and screening of diversions (NMFS 2016g).

The Action Agencies have been funding and implementing tributary habitat improvement actions in this DPS as part of mitigation for the CRS since 2007. These actions have included protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat, actions targeted at addressing the limiting factors identified above (BPA et al. 2013, 2016). Cumulative metrics for these action types for MCR steelhead from the years 2007–2019 are shown in Table 2.8-10.

Table 2.8-10. Tributary habitat improvement metrics: MCR steelhead, 2007–2019 (USACE 2020, McLaughlin 2020).

Action Type*	**Amount Completed**
Acre-feet/year of water protected *(by efficiency improvements and water purchase/lease projects)*	138,523
Riparian acres protected *(by land purchases or conservation easements)*	51,607
Riparian acres improved *(to improve riparian habitat, such as planting native vegetation or controlling noxious weeds)*	9,341
Miles of enhanced or newly accessible habitat *(by providing passage or removing barriers)*	2,111
Miles of stream complexity improved *(by adding wood or boulder structures or reconnecting existing habitat, such as side channels)*	281
Miles protected *(by land purchases or conservation easements)*	1,668
Screens installed or addressed *(for compliance with criteria or by elimination/consolidation of diversions)*	352

*Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have improved and will continue to improve habitat in the targeted populations as these projects mature, and that fish population abundance, productivity, spatial structure, and diversity will respond positively. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population, and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. The benefits of some of these actions will continue to accrue over several decades. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends (see Appendix A for further discussion of the types of habitat changes expected from various action types, the expected timeframes for those changes, and the challenges of measuring the effects of habitat improvement actions).

RME has been underway in this DPS to evaluate changes in habitat and fish populations as a result of habitat improvement actions. Available empirical evidence supports our view that these actions are improving habitat capacity and productivity, and that fish are responding. Appendix A summarizes the scientific foundation for our determination, including relevant RME information from throughout the Columbia River Basin and other lines of evidence that we considered regarding the effects of habitat improvement actions. It also discusses the complexities of evaluating the effects of habitat restoration on fish populations (see Appendix A, also see NMFS 2014a, Hillman et al. 2016, ISAB 2018, Griswold and Phillips 2018, Haskell et al. 2019).[294]

Best available science and information also indicate that there remains additional potential for improvement (NMFS 2009a, 2016g), although habitat conditions, limiting factors, and the potential for improvement vary among populations. NMFS' most recent 5-year status (NMFS 2016g) identified increasing summer stream flows in the Yakima, Umatilla, Walla Walla, and John Day subbasins as the greatest opportunity in tributary habitat to advance recovery for this DPS. NMFS staff have also identified high priority limiting factors and near-term actions within each MPG: 1) Yakima MPG: improve mainstem smolt outmigration flows, 2) John Day MPG: address elevated stream temperatures, low summer streamflow, and lack of juvenile rearing habitat, 3) Cascade Eastern Slope MPG: increase juvenile rearing habitat by increasing summer baseflows and decreasing summer water temperatures, and 4) Umatilla/Walla Walla MPG: improve passage at Mill Creek and Nursery Bridge.

Density dependence has been observed in MCR steelhead populations (ISAB 2015), which indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stages and limiting factors, would be likely to improve overall population abundance and productivity.

In summary, while tributary habitat conditions are likely improving in some places as a result of habitat improvement actions and improved land use practices, in general, tributary habitat conditions are still degraded. These degraded habitat conditions continue to negatively affect MCR steelhead abundance, productivity, spatial structure, and diversity. In addition, ongoing development and land-use activities may also continue to have negative effects. The potential exists, however, to further improve tributary habitat capacity and productivity in this DPS.

2.8.2.5 Estuary Habitat

The Columbia River estuary provides important migratory habitat for MCR steelhead populations. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with

[294] The goal of the tributary habitat program is to implement tributary habitat actions that address priority limiting factors and improve population abundance, productivity, spatial structure, and diversity. Measuring the effects of habitat restoration for fish and other aquatic and riparian biota is "one of the great challenges of river and stream conservation" (ISAB 2018). To draw conclusions about the effectiveness of this program, we evaluated multiple lines of evidence, including knowledge of the basic relationships between fish and their tributary habitat, findings in the scientific literature about how changes in fish habitat affect fish populations, literature on the physical and biological effectiveness of tributary habitat improvement actions, correlation analyses, results from monitoring in the Columbia River basin designed to evaluate the effects of various actions on tributary habitat limiting factors and on salmon and steelhead response, and the results of life-cycle models. Those lines of evidence and our conclusions are summarized in Appendix A.

flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review (NMFS 2016g), have improved access and connectivity to floodplain habitat. From 2007 through 2019, the Action Agencies implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents a more than a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling steelhead (Johnson et al. 2018). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Floodplain habitat restoration affects the performance of juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but the prey items produced in wetlands (primarily chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) are also exported to the mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Juvenile steelhead moving through the mainstem or off-channel habitats behind islands and other landforms then have access to these food items. Thus, while most steelhead may not enter a tidal wetland channel, they derive benefits from wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry. Blood serum levels of IGF-1 (Insulin-like growth factor-1) for yearling steelhead collected in the estuary were higher than are typically found in hatchery fish before release, suggesting that prey quality and quantity in the estuary were sufficient for growth (PNNL and NMFS 2020). However, variation in IGF-1 levels was substantial (two to three times higher in some individuals than in others) (Beckman 2020), both within and between genetic stocks, indicating differences in feeding and migration patterns. Continuing to grow during estuary transit may be part of a strategy to escape predation during the ocean life stage through larger body size.

As discussed in Section 2.8.2.1.2 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007), from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as it receives contaminants from more than 100 sources that discharge into a river and numerous sources of runoffs (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at

Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing the fact that contaminants are widespread throughout the estuarine food web (Fuhrer et al. 1996, Tetra Tech 1996, LCREP 2007). This includes the bodies of insects, which salmon in turn ingest. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.8.2.6 Predation

A variety of bird and fish predators consume juvenile MCR steelhead on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. Predation in the estuary and in the migration corridor, and management measures to reduce the effects of predation, are discussed below.

2.8.2.6.1 Avian Predation

Avian Predation in the Lower Columbia River Estuary

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river’s estuary and plume is about 40 percent of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including MCR steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island, where marine forage fish were available to diversify the terns’ diet. Roby et al. (2017) estimated that terns on East Sand Island consumed an average of 5.1 million smolts per year, a 59 percent reduction from when the colony was on Rice Island.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this DPS were about 17.1 and 7.5 percent, respectively, before efforts to manage the size of these colonies (Evans and Payton 2020). Tern predation rates have decreased to 10.1 percent since 2007, a statistically credible difference (Appendix B). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on MCR steelhead in 2003 to 2015 was 7.5 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge[295] where smolts are likely to constitute a larger proportion of the diet. The average annual predation rates on MCR steelhead reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (5.4 during 2015 to 2017 and 0.4 percent in 2018) therefore cannot be directly compared to those before management began, and are likely to underestimate predation rates in the estuary.

Avian Predation in the Hydrosystem Reach

The following paragraphs describe avian predation in the mainstem Columbia River from the tailrace of Bonneville Dam to the confluence of the Yakima River.

MCR steelhead survival is affected in the mainstem by avian predators that forage at the mainstem dams and in the reservoirs. The 2008 biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. These efforts have reduced avian predation on juvenile salmon at the dams. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84 to 94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates to variation in the number of foraging gulls rather than to deterrence efforts, but imply that deterrence activities provide some (unquantifiable) level of protection.[296]

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[295] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

[296] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams" (Zorich et al. 2012).

Juvenile MCR steelhead are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been focused on keeping terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015, and similar efforts are in progress at Goose Island in Potholes Reservoir. Although Evans and Payton (2020) do not report predation rates on MCR steelhead at the Blalock Islands, it is likely that they have been higher since management activities began at Crescent and Goose Islands, as reported for SRB and UCR steelhead.

Predation by gulls was not considered to warrant management actions at the time the IAPMP was developed, and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from the SRB steelhead DPS by gulls on Miller Rocks averaged 7.2 percent during 2007 to 2019 (Evans and Payton 2020; Appendix B); predation rates on UCR steelhead averaged 8.2 percent. Based on data for these steelhead DPSs, predation rates on MCR steelhead may have averaged more than 2 percent per colony for gulls nesting on Island 20, Badger Island, Crescent Island, and the Blalock Islands in recent years (Evans and Payton 2020).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on MCR steelhead after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any potential gain in numbers of smolts over estimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different although related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns, but the ocean conditions that outmigrants experience, such as poor prey availability and the number and behavior of predators, which can trigger compensatory effects, will also be important.[297]

With respect to management of terns in the estuary, Caspian terns nesting on East Sand Island were eating an average of 17.1 percent of juvenile MCR steelhead outmigrants per year before management actions reduced the size of that colony and 10.1 percent per year thereafter (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (17.1 percent) and the average 7 percent per year decrease achieved by reducing the size of the tern colony, it is likely that this management measure led to increased adult returns for MCR steelhead, before the downturn in ocean conditions overwhelmed improvements in freshwater survival. For double-crested cormorants, reduction of the colony on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 7.5 percent to less than 1 percent. However, in this case, predation rates on MCR steelhead are likely to have increased because the thousands of these birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[298]

2.8.2.6.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia and Snake Rivers followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62

[297] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

[298] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). From 2015 to 2019, an annual average of 42 adult and 198 juvenile steelhead per year were incidentally caught in the Sport Reward Fishery (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to DPS, we assume that some were MCR steelhead.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). They did not report killing or handling any adult or juvenile steelhead during the 5-year period. In addition, they caught, but did not remove, an annual average of 967 smallmouth bass and 379 walleye at the two dam angling sites combined over the last 5 years (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). The Oregon and Washington Departments of Fish and Wildlife, which manage these two non-native predator species, are currently discussing the possibility of removing smallmouth bass and walleye from the system when captured by the Dam Angling Program (as with pikeminnow). Both agencies have already removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these species, in addition to pikeminnow, both in the lower Columbia River and the CRS reservoirs (i.e., hydrosystem reach), would incrementally improve juvenile salmonid survival during their migration to the ocean.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile steelhead, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. Williams et al. (2018) found a lower than average abundance (1990 to 2018) for northern pikeminnow in The Dalles and John Day Reservoirs along with a two to three times higher than average abundance for smallmouth bass and walleye in the same reservoirs. With the exception of the John Day forebay area, smallmouth bass abundance index values calculated for 2018 were the highest observed since 1990. Abundance index values provide a means to characterize relative predation impacts (Williams et al. 2018). Similarly, in 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP, as well as a substantial increase in their predatory impact in the lower Snake reservoirs since program design and implementation. Also compared to previous years, walleye were relatively abundant in both The Dalles and John Day Reservoirs during 2018 spring sampling, but few were encountered during the summer sampling. The greatest walleye abundance indices were observed in the John Day Dam tailrace and mid-reservoir, with the tailrace value being the highest recorded abundance to date (Williams et al. 2018). These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal still remains unclear. The complexity of inter-species interactions, combined with inter-reservoir variability and environmental variability, make this a difficult research question to answer without a more intensive sampling and evaluation program (Williams et al. 2018, Winther et al. 2019). However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the steelhead that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including MCR steelhead. As such, it likely continues to benefit the DPS.

2.8.2.6.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions, Steller sea lions, and harbor seals consume adult salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. A small number of California sea lions (0 to 5) have also been observed in Bonneville Reservoir. ODFW counted the number of individual California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, from 1997 to 2017. Pinniped counts at the East Mooring Basin during July and August, when MCR steelhead are migrating, remained stable during 2008 to 2016 (Table 2.8-11), with a maximum count of 423 California sea lions in August 2014 (Wright 2018).

Table 2.8-11. Maximum monthly counts of California sea lions at Astoria, Oregon, East Mooring Basin, 2008–2017 (counts ended in June 2017, so more recent data are not available; NA) (Wright 2018).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2008	40	56	67	126	162	46	6	191	213	204	273	157
2009	27	42	84	118	173	45	38	346	376	241	89	84
2010	58	93	136	229	216	157	29	316	356	265	98	54
2011	19	42	77	155	242	126	11	302	246	85	159	106
2012	20	27	82	240	201	92	19	212	187	147	91	21
2013	37	149	595	739	722	153	8	368	377	208	182	100
2014	237	586	1420	1295	793	90	32	423	492	369	94	126
2015	260	1564	2340	2056	1234	623	37	394	1318	459	84	208
2016	788	2144	3834	1212	1077	620	3	291	1004	878	235	246
2017	1498	2345	808	1131	1204	573	NA	NA	NA	NA	NA	NA

Estimates of steelhead predation by pinnipeds in the lower Columbia River estuary (i.e., downstream of the Bonneville tailrace) are not available for the late-summer time period. Instead, monitoring efforts have focused on California sea lion predation on SR spring/summer Chinook salmon during January to May (e.g., Rub et al. 2019). Excluding the known impact in the Bonneville Dam tailrace, average pinniped impacts to summer migrating adult MCR steelhead through the lower Columbia River are likely relatively minor because pinniped counts are generally low in July and August (when most MCR steelhead pass Bonneville Dam), and they are mixed with relatively abundant fall Chinook salmon migrating in September and October.

An authorization from NMFS under the MMPA has allowed the states of Oregon and Washington to implement hazing and removal of California sea lions in an effort to improve the survival of adult salmonids in the lower river. From 2008 to 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019, respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between RM 112 and McNary Dam (RM 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

Pinniped presence in the Bonneville tailrace during the MCR steelhead migration in the summer and fall, has increased in the last 6 years (Tidwell et al. 2020). Steller sea lions in particular aggregate at the base of the dam in the late summer when MCR steelhead are present. Between July 21 and December 31, 2017, Tidwell et al. (2018) documented an average of 14.5 Steller sea lions at Bonneville Dam and, during many sampling periods, counted more than 20 individuals. A small number of California sea lions have also been observed in Bonneville Reservoir but have since been removed. The percentage of steelhead estimated to be consumed by pinnipeds in 2018 was 1.6 percent (Tidwell et al. 2020), and we assume that the percentage of MCR steelhead consumed was similar.

Due to the repeated entry of sea lions into the adult ladders at Bonneville Dam, the Corps began constructing physical exclusion devices in 2006 to block pinnipeds but allow fish passage. These gates, called sea lion exclusion devices, are installed at all eight ladder entrances at Bonneville when MCR steelhead and pinnipeds are present (Tidwell et al. 2017). In addition, the Corps has installed smaller physical exclusion gratings on the 16 FOGs along the face of Bonneville Dam Powerhouse 2 that allow fish to enter the collection channel and pass via the Washington shore ladder. The sea lion exclusion devices and FOGs successfully prevent pinnipeds from entering the adult fish ladders, and thus further minimize opportunities to prey on MCR steelhead.

2.8.2.7 Research, Monitoring, and Evaluation Activities

The primary effects of past and present CRS-related RME programs on MCR steelhead are associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates; and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were MCR steelhead. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the MCR steelhead DPS by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of MCR steelhead that have been handled (or have died) each year using the average annual take reported from 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of MCR steelhead associated with the Smolt Monitoring Program and the CSS were as follows:
  - Zero hatchery and zero natural-origin adults were handled.
  - Zero hatchery and zero natural-origin adults died.
  - Zero hatchery and 1,686 natural-origin juveniles were handled.
  - Zero hatchery and three natural-origin juveniles died.

- Average annual estimates for MCR steelhead handling and mortality for all other fish RME programs were as follows:
  - Zero hatchery and five natural-origin adults were handled.
  - Zero hatchery and zero natural-origin adults died.
  - 43 hatchery and 9,235 natural-origin juveniles were handled.
  - Zero hatchery and 434 natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) of MCR steelhead associated with these elements of the RME program has, on average, affected less than 1 percent (0.02 percent) of the natural-origin adult run (recent 5-year average at Bonneville Dam) and 2.7 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects MCR steelhead.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the DPS level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.8.2.8 Critical Habitat

The condition of MCR steelhead critical habitat in the action area without the consequences caused by the proposed action is reflected in the impacts on the PBFs essential for conservation discussed above and summarized in Table 2.8-12. Across the action area, land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use and water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for steelhead production have been weakened. Conditions in the hydrosystem reach were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decade since critical habitat was designated for MCR steelhead have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.8-12. Physical and biological features (PBFs) of designated critical habitat for MCR steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater spawning sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices) has reduced the quality of freshwater spawning sites for all populations. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning sites for all populations. Diminished stream flow (water withdrawals, droughts) has reduced the quantity and quality of freshwater spawning sites for all populations. Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced the quality of freshwater spawning sites for all populations. Many tributary habitat improvement actions implemented in the middle Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to freshwater spawning sites.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality, forage, and natural cover.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater rearing sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations. Elevated temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices, mining practices) have reduced the quality of freshwater rearing sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices) has reduced the quality of freshwater rearing sites for all populations.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater rearing sites for all populations. Many tributary habitat improvement actions implemented in the middle Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to protect and improve instream flow, improve habitat complexity, improve riparian area condition, reduce fish entrainment, and remove barriers to freshwater rearing sites.
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover.	*Effects in the migration corridors apply to all populations of MCR steelhead:* Alteration of the seasonal flow regime in the lower Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderately negative effect in lower flow years. Alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in late summer and fall (hydrosystem development and operations).[1] Cooler spring temperatures do not affect the functioning of the mainstem as a migration corridor for juvenile steelhead. However, adult MCR steelhead enter the lower Columbia River during summer so that this alteration adversely affects the functioning of water quality in the migration corridor for adults. Reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume (hydrosystem development), may have reduced "natural cover" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining). The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		release, and to use “environmentally acceptable lubricants” where feasible. Delay and mortality of some juveniles at up to four and of adults at up to eight CRS dams on the mainstem Columbia River has increased obstructions in the migration corridor. Increased exposure of juveniles to TDG in the lower Snake and Columbia Rivers and at least 35 miles below Bonneville Dam during involuntary[2] and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor for juvenile steelhead. The incidence of adverse effects (GBT in juveniles and adults) appears to have been small (1 to 2 percent) in recent years with TDG up to 120 percent. The operation of the hydrosystem has increased obstructions by creating conditions that delay and injure/kill some juveniles and a smaller proportion of adults in the migration corridor. However, the functioning of the migration corridor has increased substantially for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult steelhead during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past the dams or overwintering within the fish facilities or turbine units). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile steelhead because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems). Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for avian and fish predators in the tailraces of mainstem dams. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, propane cannons, and limited amounts of lethal take. Fish predation is addressed by dam angling at several dams. Delays of adults at the ladder entrances at Bonneville Dam has increased the risk of pinniped predation (excessive predation related to hydrosystem development and operation) in the migration corridor. Pinniped predation is addressed by the use of sea lion excluder devices at the fishway entrances at Bonneville Dam.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, and juvenile and adult forage.	*Effects in estuarine areas apply to all populations of MCR steelhead:* Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling Chinook salmon by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the Caspian Tern Management Plan on East Sand Island is reducing excessive predation in the estuary, but depending on ocean conditions and compensatory effects, may not be increasing adult returns for MCR steelhead. Implementation of the Double-crested Cormorant Management Plan may have contributed to, or at least coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island.
Nearshore marine areas[3]	Free of obstruction and excessive predation with water quality, quantity, and forage.	Concerns about increased pinniped predation and adequate forage.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Spill is characterized as "involuntary" when water is spilled over a dam's spillway because it cannot be stored in a reservoir behind the dam or passed through turbines to generate electricity, such as during maintenance activities, periods of low energy demand, or periods of high river flow. Involuntary spill is most common in the spring.

[3] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Habitat quality in tributary streams in the Interior Columbia Recovery Domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the Interior Columbia River Recovery Domain (NMFS 2016g).

The general effects of mainstem and tributary dams on the functioning of critical habitat for MCR steelhead are:

- Altered juvenile and adult passage survival at dams with passage facilities (obstruction).
- Altered flows and seasonal timing (reduced water quantity).
- Altered seasonal temperatures and elevated dissolved gas (reduced water quality).
- Sediment transport and turbidity (reduced water quality).
- Altered food webs, including both predators and prey (reduced prey production and increased numbers of predators, including non-natives).

Habitat quality of migratory corridors in this area was substantially affected by the development and operation of the CRS dams and reservoirs in the mainstem lower Snake and Columbia Rivers, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and upper Columbia River basins. Hydrosystem development modified natural flow regimes, resulting in warmer late summer/fall water temperatures. Changes in fish communities led to increased rates of piscivorous predation on juvenile salmon and steelhead. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines and juvenile bypass systems, have also killed some out-migrating fish. However, some of these conditions have improved. In previous CRS consultations, the Action Agencies have implemented measures in the juvenile and adult migration corridors including 24-hour volitional spill, surface passage routes, upgrades to juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

In addition, basinwide water management activities, including the operation of the CRS water storage projects for flood control, power generation, and water withdrawals have substantially reduced average monthly flows at Bonneville Dam during May to July and increased them during October to March compared to an unregulated system. Reduced spring flows, combined with the existence of mainstem dams, increased travel times during the juvenile outmigration period for MCR steelhead, increasing the risk of predation. Since salmon and steelhead were listed and critical habitat was designated under the ESA, the Action Agencies have made substantial changes to minimize these operational effects by limiting storage reservoir elevations to minimums needed for flood risk management and passing more water during the spring refill period. By taking these actions, the Action Agencies have increased flows in the spring and summer, which helps replicate the natural hydrograph. As a result, the functioning of the migration corridor has been improved by reduced exposure to predators, increased turbidity (which can provide visual cover), and increased access to cover and prey in nearshore mainstem habitat.

The functioning of juvenile rearing and migration habitat for MCR steelhead in the lower Columbia River estuary has been reduced by the conversion of more than 70 percent of the original marshes and spruce swamps to industrial, transportation, recreational, agricultural, or urban uses. Water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. Reduced sediment delivery to the lower river and estuary, combined with in-water structures that focus flow in the navigation channel and bank armoring, have altered the development of habitat along the margins of the river. All of these changes have reduced the availability of prey for smolts between Bonneville Dam and ocean entry.

In the hydrosystem reach, altered habitats in project reservoirs and tailraces create more favorable habitat conditions for fish predators; the latter include native northern pikeminnow and non-native walleye and smallmouth bass. The effects of the nonnative species and those of pikeminnows, to the extent the latter's predation rates are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the juvenile migration corridor. Similarly, sea-lion predation on adult MCR steelhead in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary is a natural phenomenon and is not excessive predation in the context of an effect on the functioning of critical habitat.

Restoration activities in tributary spawning and rearing areas and in the estuary that are addressing habitat quality and complexity, and improved functioning of the juvenile migration corridor (e.g., 24-hour and flexible spill, new surface passage structures, and improved spillway designs) have improved the baseline condition for some components of the PBFs. However, more restoration is needed before the PBFs can fully support the conservation of MCR steelhead.

2.8.2.9 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of MCR steelhead, including recent biological opinions issued for the MCR steelhead DPS and key emergent or ongoing habitat concerns (NMFS 2016g). From January 2015 through May 22, 2020, we completed 532 formal consultations that addressed effects to MCR steelhead.[299] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat, improve riparian conditions, increase channel complexity, and increase instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more than, and typically less than, a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in

[299] PCTS data query July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.8.2.10 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of MCR steelhead populations. Recent improvements in passage conditions at mainstem CRS dams, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, tributary habitat improvements, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. The recovery plan (NMFS 2009a) identified habitat degradation, hydropower systems, harvest, hatcheries, changes in estuarine habitat, climate change, inadequacy of regulatory mechanisms, fluctuating ocean cycles, and predation as limiting factors that continue to negatively affect MCR steelhead populations.

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for MCR steelhead, as described above. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of some of these PBFs of critical habitat. For example, surface passage structures and spill operations have reduced obstructions for juvenile MCR steelhead at CRS dams in the lower Columbia River. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. Similarly, projects that have protected or restored tributary habitat have improved the functioning of the freshwater spawning and rearing sites. However, the factors described above continue to have negative effects on PBFs.

2.8.3 Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species

(e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.8.3.1 Effects to Species

2.8.3.1.1 Spill and Seasonal Flow Operations

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams. The intent of flexible spill operations is to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem.[300] Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG spill ("gas cap spill") for a minimum of 16 hours per day, and under lower spill levels ("performance standard spill") for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill at all hours. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs maximum spill constraint) for 16 hours per day with 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan, unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in performance standard spill periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.8-13.

Table 2.8-13. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%

[300] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.8-14. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.8-14. Proposed summer spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[2]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March, decreased flows from May through August, and little change in flows in April and September) described in the Environmental Baseline section will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in all project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce high TDG events associated with spill in the winter, which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. The proportional effect on flow is higher in the lower Snake River than in the lower Columbia River due to its smaller flow volume. Nonetheless these flow changes do transfer into the lower Columbia River and have the potential to affect MCR steelhead in the lower Columbia River. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al.

2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.8-6).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

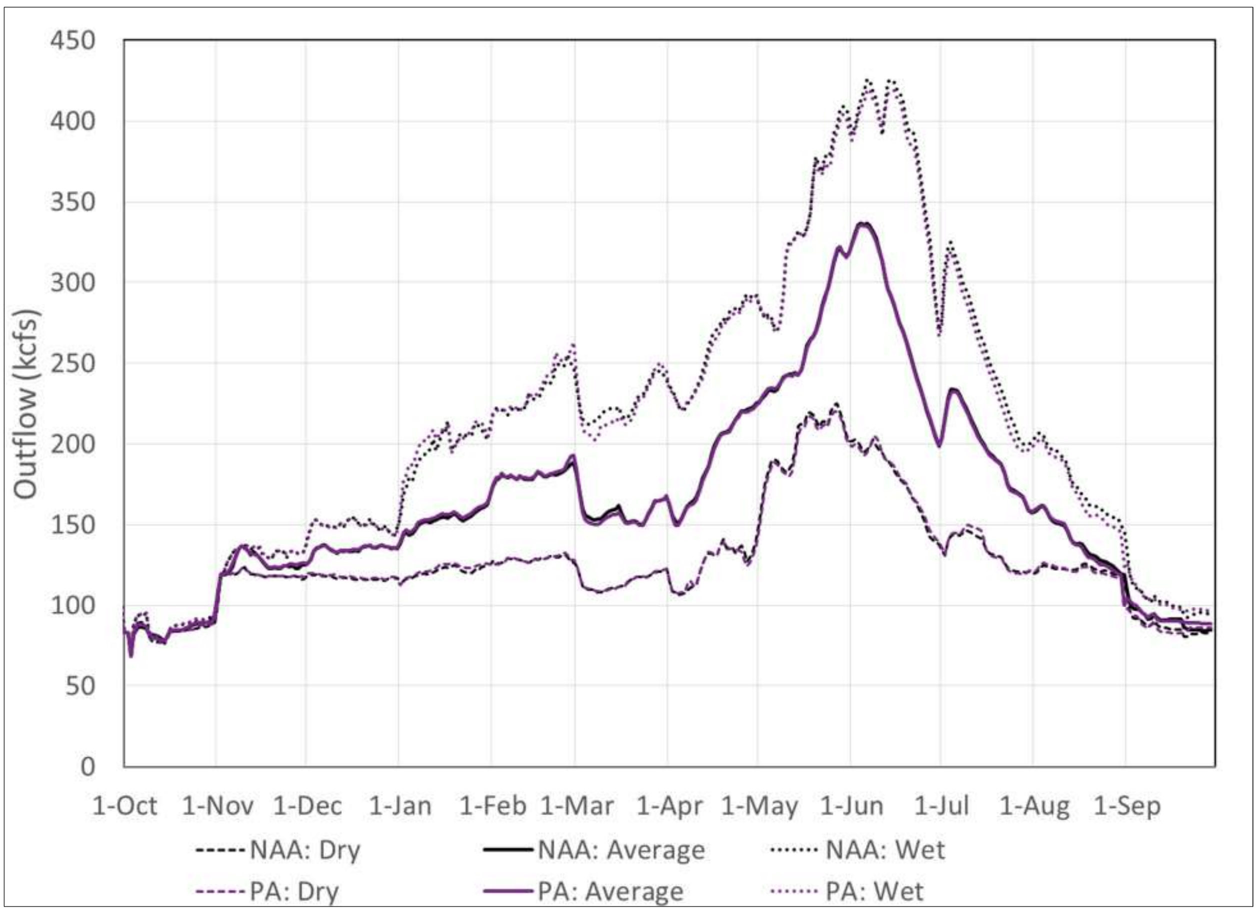

Figure 2.8-6. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

Juvenile MCR steelhead migrate through the lower Columbia River primarily in April to early June , and the Action Agencies will operate to meet seasonal flow objectives to support juvenile migrants during that period. Adult MCR steelhead migrate primarily in July to September. The proposed change in flow would be too small to affect river temperature during the adult migration period, which would be the attribute of highest concern. The associated effects on MCR steelhead smolts or adults should not change from recent conditions by a meaningful amount.

The effects of the proposed hydrosystem operations and the non-operational measures on MCR steelhead and its habitat are described below.

2.8.3.1.2 Water Quality

The operation of the CRS will continue to affect water quality parameters in the mainstem migration corridor. This includes delayed spring warming, delayed fall cooling, and reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs.

Taken together, the proposed measures at Grand Coulee Dam would influence reservoir elevations at Lake Roosevelt; however, effects on water temperature would be negligible. At Chief Joseph Dam, monthly outflows are predicted to be similar to or about 1 percent less for all types of water years, and tailrace temperatures are expected to be similar to existing conditions. Tailrace temperatures should not be measurably altered by the proposed action and are predicted to continue to exceed the Washington State water quality standard for August and September (7-day average of the daily maximum temperature of 63.5°F). There will be little difference in temperature between Grand Coulee Dam and Chief Joseph Dam, showing that water temperatures below Lake Roosevelt are unchanged through Rufus Woods Lake.

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacity spill. These events will continue to occur most frequently in May and June but may also occur in other months.

Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). For MCR steelhead smolts, the proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of McNary Dam to at least 35 miles downstream of Bonneville Dam. Individuals from all "upstream" populations and MPGs would be exposed to a greater extent than those from "downstream" populations and MPGs. Smolts typically migrate at depths that effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020). Data from all fish sampled in the CRS Gas Bubble Trauma Monitoring Program (1996 to 2019) indicate that signs of GBT were almost non-existent below 120 percent TDG, increased slightly between 121 and 125 percent TDG, and then increased in both incidence and severity when TDG levels exceeded 125 percent (FPC 2019). Thus, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality of juvenile MCR steelhead.

The majority of adult MCR steelhead migrate after the spring spill period and will not be affected by the proposed flexible spring spill operation. Some adults from this DPS hold up in the larger rivers over the winter and then continue upstream (or, if they overshoot their natal stream, drop back downstream) through the dams in the spring (Keefer et al. 2016). Thus, only a small portion of the DPS—those holding overwinter and continuing their migration the following year—could be exposed to the increased spill associated with the flexible spring spill operation. Adults also migrate at depths that reduce the effective exposure to TDG through depth compensation mechanisms. Thus, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality for adults that are exposed.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[301] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream,

[301] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on MCR steelhead are likely to be very small and are not expected to detectably affect reach survival estimates.

Sediment Transport

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency especially during the spring freshet. The increased water transparency hypothetically increases the exposure of MCR steelhead juveniles to predators (Gregory 1993, Gregory and Levings 1998, Sontag 2013) and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile MCR steelhead spend only days to weeks in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

2.8.3.1.3 Project Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems (BPA et al. 2020). Maintenance activities evaluated and covered under this opinion can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance, as summarized in Section 1.3 of this opinion and in further detail in BPA et al. (2020).

Fishway structures (e.g., fish ladders, screens, bypass systems) will be routinely maintained and temporarily removed from service on a scheduled basis during the established in-water work period (December to March), in accordance with the Fish Passage Plan and coordinated through FPOM to minimize impacts to adult and juvenile migrants. At Bonneville Dam, routine dredging in the forebay and rock removal in the spillway will occur every year or two to ensure reliable operation and structural integrity of the fishways. Turbine unit maintenance is planned at all dams and will be coordinated through FPOM to minimize and avoid delay, injury, and mortality.

Routine outages of fishways are necessary to maintain reliability, but these temporary outages can cause delay and mortality for adult and juvenile migrants that attempt to migrate at the time of the outage. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of, MCR steelhead that are migrating, and these effects will occur at extremely low levels similar to what was observed in the recent past. Passage delay and conversion rates will be monitored and maintenance schedules may be modified through FPOM or adaptive management if evidence indicates elevated delay and mortality are occurring.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization and major rehabilitations. Non-routine maintenance expected in the timeframe of the proposed action includes turbine replacement at McNary Dam which is expected to begin within the next 15 years. At John Day Dam, turbine replacement may begin, but it is uncertain at this time if it will be completed, within the 15-year period of the proposed action. The proposed maintenance at Grand Coulee could result in outages and additional spill in limited situations, but changes to total outflows are not expected. Non-routine maintenance (related to turbines or spillbays) expected in the proposed action can increase TDG during uncontrolled spill by temporarily reducing powerhouse capacity and may cause suboptimal tailrace conditions which can delay passage. The installation of improved fish passage turbines will likely improve turbine survival and reliability once completed. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce risk to adults and juveniles.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated with NMFS and through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize negative effects on fish. Fish passage metrics will be monitored with counts and PIT tags to ensure unscheduled maintenance activities do not result in negative impacts to the ESU.

Overall, scheduled maintenance activities are expected to continue to negatively affect small numbers of adult MCR steelhead annually. A few adults will be delayed or die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. Very few juveniles will likely be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult MCR steelhead will likely continue to result in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as prioritizing adjacent turbine units and providing additional attraction to other passage routes will continue to minimize the impacts.

2.8.3.1.4 Adult Migration/Survival

Adult survival rates for MCR steelhead are expected to continue to average about 96.4 percent (2014 to 2018 average) from Bonneville to McNary Dam under the proposed action for populations passing each of the four lower Columbia River Projects. Survival rates for adults for populations passing three dams, or only two dams, are expected to continue at about 97.5 percent and 98.7 percent, respectively. The great majority of adult MCR steelhead migrate after the flexible spring spill operation has ended. For those few adults that overwinter in the lower Columbia River and continue migrating upstream the following spring, tailrace conditions at John Day Dam during low to moderate flows could be degraded by the increased spill levels (16 hours per day) resulting from the flexible spring spill operation during the spring spill period. While this operation could negatively affect passage conditions for migrating adults (i.e., the ability to find fishway entrances), 8 hours of performance level spill should be sufficient to prevent any measurable impacts to passage or adult survival.

The flexible spill operations should not negatively affect passage conditions for MCR steelhead at the other lower Columbia River dams. Keefer et al. (2016) estimated that mean annual fallback rates were about 6 to 9 percent at the lower Columbia River dams. Fallback rates, which are associated at many dams with higher spill levels, will likely increase slightly at the lower Columbia River dams (except The Dalles), but this effect will be small because of the scarcity of MCR steelhead adults present. Adult fallback has been associated with longer migration times and reduced survival rates. However, the additional fallback would most likely happen through a spillbay (rather than a turbine unit or screened bypass system), which would be expected to increase the survival of these fish, relative to the other passage routes (Colotello et al. 2013, Normandeau et al. 2014). This would potentially offset some of the potential impact of increased fallback rates associated with increased spill levels under the proposed action. In addition, adaptive management processes can be used to identify (daily or weekly estimates of fallback-reascension rates) and remedy (through in-season management processes) excessive fallback or migration delays, if it occurs, as was done for adult delays at Little Goose Dam in recent years.

In addition, many MCR steelhead adults overshoot their natal streams, which tend to be warmer than the mainstem Columbia or Snake Rivers in late July and August, pass upstream of McNary or other dams, hold in cooler water, and then drop back downstream in the fall, or early the following spring to reach their natal streams. The proposed action includes a study (begun in September 2019) assessing several spill strategies using a single spillbay at McNary Dam to determine the extent to which they could provide safe and effective downstream passage for overshooting adults outside the spring and summer spill periods for juveniles. This research has the potential to substantially improve adult survival for the John Day and Umatilla River populations.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. This change will affect adult MCR steelhead that may be migrating after that date in August by improving adult ladder attraction conditions and reducing fallback. However, individuals that fell back would experience greater risk because they would be more likely to pass via turbines and juvenile bypass systems instead of the spillway. A substantial portion of MCR steelhead will be migrating when this occurs. While spill will be reduced during this period compared to baseline, a spillway route will still be provided for fish that intend to fall back. The available information on steelhead fallback indicates adult steelhead prefer to utilize spillway routes over turbine routes if made available, and the reduced amount of spill provided in late August will still be sufficient for effective attraction and passage survival (Ham et al. 2012). Based on the correlation between spill and fallback rates, the overall operation will likely lead to a minor reduction in project fallback rates, with the possibility of a very small increase in turbine passage. This will likely result in a small positive effect for adults or no net measurable change in survival, however, NMFS will continue to monitor PIT detections, fallback rates, conversion rates, and adult counts for adaptive management.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14. The increase in operation range is expected to slightly reduce the average flow rate in the reservoirs. The PIT tag information suggests a portion of adult MCR steelhead migrate into the Snake River on an annual basis and some fish will experience this flow condition, but the minor flow reduction is not expected to measurably affect survival for adults.

The Action Agencies propose to increase the forebay operating range at John Day Dam. During the juvenile fish passage season (April 10 to August 31), John Day Reservoir would be operated within 2 feet of MIP (262.5 to 264.5 feet), except during the spring spill period, when the John Day forebay operating elevation window will be increased. From April 10 to June 1–15, John Day Reservoir elevation will be held between 264.5 feet and 266.5 feet to deter piscivorous Caspian terns from nesting in the Blalock Islands Complex (see Section 2.2.3.1.10). Following this operation, John Day Reservoir elevation would return to MIP +2 feet operation through August 31. The increase in operating range is expected to slightly reduce velocities in John Day Reservoir, but the velocity change is not expected to affect adult migration timing or survival rates.

Power generation at Snake River projects may cease between 2300 and 0500 hours between October 15 and February 28. This operation will end no later than 2 hours before dawn between October 15 and November 30. During the operation between December 15 and February 28, daytime hours will no longer be excluded from this operation, and up to 3 hours of daytime cessation may occur. PIT-tag data indicate that some adult MCR steelhead will migrate through and overwinter in the Snake River during this operation, but past zero generation operations have not produced observably negative impacts for MCR steelhead, so we expect that this operation will not negatively affect adult migration or survival for this ESU.

The proposed operations at Libby Dam, Hungry Horse Dam, and Grand Coulee Dam should not measurably affect adult migration or survival because the flow alterations in the Columbia River are relatively small (less than 2 kcfs measured at Bonneville Dam; see discussion above) during the months when these fish migrate. The small reduction of flow would not be sufficient to affect river temperature, which would be the most relevant effect influencing adult migration success. The proposed operation at Dworshak Dam should not affect adults because any potential flow reduction would only occur in high flow years and thus not add risk to migrating adults.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as this produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action should only occur during higher flows in the spring and should not measurably affect adult MCR steelhead that primarily migrate in the summer and fall. Kelts and early migrating or overwintering adult UCR steelhead could potentially be exposed to these operations if they were to fall back through a unit when these operations are occurring, but these instances should be very rare and any negative effects should be extremely minimal.

2.8.3.1.5 Juvenile Migration/Survival

The Action Agencies propose to continue to provide fish passage spill (conventional and surface passage), operate juvenile bypass systems, and other operations (e.g., ice and trash sluiceways, Bonneville corner collector, etc.) for juvenile passage at the four lower Columbia River dams. Surface passage structures exist at all four lower Columbia dams, and three of them have juvenile bypass systems. The Dalles Dam does not have a juvenile bypass system because of low powerhouse passage rates. Increased spill levels resulting from the flexible spring spill operation are expected to have little effect on tailrace conditions at Bonneville or McNary Dams, but will likely cause eddies to form at John Day Dam under low flow conditions. The latter would be likely to reduce the survival of juvenile steelhead passing through the spillway by a potentially small, but unknown amount. Increased spill levels at three of the four lower Columbia River mainstem dams (The Dalles Dam operation will continue spilling at 40 percent) would generally be expected to slightly increase direct dam passage survival rates of inriver migrating smolts as spillway survival rates generally exceed those in the juvenile bypass systems or through the turbine units. Overall, the survival of inriver migrating juvenile MCR steelhead from all populations and MPGs should increase slightly (roughly in proportion to the number of dams they pass) as a result of implementing the flexible spring spill levels at each of the eight mainstem dams. Increases in downstream migration survival are expected to increase population productivity by delivering more smolts to the ocean, resulting in more adults returning.

NMFS' COMPASS model predicts that inriver survival rates will not change substantially as a result of increased spring spill levels associated with the flexible spill operation compared to the

No Action Alternative (USACE et al. 2020). The CSS model predicts more substantial increases in juvenile survival, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillbays) will increase adult returns of the Snake River populations by about 28 percent. If this is the case, to the extent that MCR steelhead experience latent mortality associated with dams, higher spill levels would be expected to increase adult returns accordingly, but likely less than half (14 percent) that hypothesized by the CSS for SRB steelhead (28 percent), because they pass through up to half as many Federal projects (Yakima River MPG), and spill at some projects is unchanged (e.g., The Dalles Dam). The potential benefit for the other MPGs in this DPS should be substantially lower.

The proposed operations at Libby Dam, Hungry Horse Dam, Grand Coulee Dam, and Dworshak Dam will alter flows by less than 2 percent during the spring migration period. By itself, this would be expected to result in very small increases in average travel times in April and May, and small decreases in travel times in June, but should not measurably affect juvenile survival. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

The Action Agencies propose a change in pool elevation in John Day Reservoir starting April 10 and ending sometime between June 1 and June 15 to reduce predation associated with the Blalocks Island tern colony (see discussion below). Increasing the elevation of John Day Reservoir is likely to increase downstream travel time for juveniles because an increase in surface area with a given river flow will slow down the water and the fish migrating through it. However, the net effect of the John Day Reservoir and flexible spill operations, based on COMPASS modeling for UCR steelhead (see Section 2.7.3.1.5), is likely to be no, or only a very small reduction in travel time, which should provide only a very small or no benefit to juvenile steelhead migrating through this reach.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. Because MCR steelhead juveniles migrate during the spring, they will not be affected by a reduction in summer spill in late August.

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at MOP with a 1.5-foot operating range from April 3 until August 14. The increase in operating range will not affect MCR steelhead juveniles migrating in the Columbia River.

Power generation at Snake River projects may cease for short periods between October 15 and February 28 and will result in no flow past the projects in the Snake River during these periods. Because they are not present in the Snake River, no MCR steelhead juveniles migrating in the Columbia River will be measurably impacted by this operation.

As described above (see Section 2.8.3.1.4), under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, but the number of juveniles affected should be extremely low because of the limited timeframe.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure, would slightly reduce turbine unit survival for juvenile salmonids passing through the turbine units, and would slightly increase powerhouse passage rates of MCR steelhead juveniles. These flow levels would be expected to occur in up to 20 percent of the years at McNary Dam and up to 5 to 10 percent of the years at all other projects; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur.

Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units and increase powerhouse passage rates.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 6 to 27 hours per project at the lower Snake River dams, and 8 to 30 hours per project lower Columbia River dams. For this same time period, the maximum potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is 8 to 36 hours per project at the lower Snake River dams, and 8 to 80 hours per project at the lower Columbia River dams. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation and, thus, likely overestimates the duration that would actually be implemented. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of MCR steelhead juveniles between McNary and Bonneville Dams, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population, MPG, or DPS level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

COMPASS Model Results

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT tags (detection efficiencies and project and reach survival estimates) and acoustic tags (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model.

Using SRB steelhead as a surrogate, COMPASS estimates that the increased spill levels at the lower Columbia River dams resulting from the proposed action (flexible spill up to 125 percent TDG) and increased pool elevation at John Day Dam will result in the average survivals shown in Table 2.8-15 for MCR steelhead. Survivals are calibrated based on how many dams a particular MCR steelhead population must pass.

Table 2.8-15. Estimated average survivals for MCR steelhead under flexible spill up to 125 percent TDG.

Dams Passed	Populations	Estimated average survival
1	Fifteen Mile Creek	86.8%
2	Deschutes River Eastside Deschutes River Westside Deschutes Crooked River	81.1%
3	John Day River Lower Mainstem Tributaries John Day River Upper Mainstem Tributaries North Fork John Day River Middle Fork John Day River South Fork John Day River Klickitat River* Rock Creek*	64.8%
4	Touchet River Umatilla River Walla Walla River Yakima, Walla Walla Naches River Satus Creek Toppenish Creek Yakima River Upstream Mainstem	58.2%

The draft EIS used COMPASS to compare the Preferred Alternative (proposed action) to the No Action Alternative (2016 Operations), using UCR steelhead as a surrogate (USACE et al. 2020). The median model results (USACE et al. 2020, Tables 7 to 23) indicated that the flexible spring spill operations (proposed action), compared to the No Action Alternative, would:

- Have no substantive effect on juvenile travel times from McNary to Bonneville Dam (zero days).
- Have no substantive effect on juvenile survival from McNary to Bonneville Dam (minus 0.1 percent).
- Slightly increase the number of spillway passage events from Rock Island to Bonneville Dam by about 0.14.

These results support our qualitative expectations that juvenile survival rates for MCR steelhead in the lower Columbia River would not change in biologically significant ways (i.e., enough to affect the abundance or productivity of any MCR steelhead population) as a result of the proposed operation. Though it has not been explicitly applied to MCR steelhead, the CSS hypothesizes that the greatest increase in survival from increasing spill will occur in the form of a reduction in delayed mortality (CSS 2017). Since this reduction in delayed mortality is believed to occur downstream of the hydrosystem, it is not reflected in direct survival estimates. The CSS did not model MCR steelhead survival but the potential for improved juvenile survival and reduced latent mortality (higher smolt to adult returns) can be inferred from their estimates for Snake River steelhead (28 percent increase in SARs), though potential for improved adult returns is much less for MCR steelhead because they migrate past only one to four mainstem dams, rather than eight like SRB steelhead. Another possible explanation for reduced return probabilities of bypassed fish is that smaller fish and those in poorer condition tend to enter bypass systems with higher probability (Zabel et al. 2005, ISAB 2012, Hostetter et al. 2015, Faulkner et al. 2019), and smaller fish and fish in poorer condition also have lower return probability (Ward and Slaney 1988, Zabel and Williams 2002, Evans et al. 2014). This suggests that the apparent effects of juvenile bypasses on juvenile survival and adult return probability are due, at least in part, to the correlation between bypass probability and fish size and condition, and not due to bypass passage itself. Thus, increasing spill levels will incrementally increase the proportion of spillway passed fish and reduce travel times and could, assuming spillway passage survival rates are not substantially reduced as a result of poor egress and tailrace conditions, improve direct juvenile survival rates. But increasing spill levels might not increase adult returns to the extent hypothesized by the CSS. It is also important to note that since higher spill levels result in unbalanced flows between the powerhouse and spillways, which can result in degraded tailrace conditions (eddies, etc.), juvenile survival could be lower than COMPASS predicts as a result of extended tailrace delay and the potential for increased predation or increased exposure to high TDG levels at some projects.

2.8.3.1.6 Transportation

Consistent with current practices, no MCR steelhead smolts will be transported as a result of the proposed action. Any changes to transportation operations would not affect MCR steelhead because juveniles only migrate downstream of the lower Snake River collector projects.

2.8.3.1.7 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) to MCR steelhead as they migrate through the estuary (PNNL and NMFS 2018, 2020).

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty about predicting the availability of habitat restoration actions into the future and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their estuary habitat monitoring program, the CEERP component that provides a basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and be initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the action effectiveness monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program will show that these floodplain reconnections are enhancing conditions for salmonids such as MCR steelhead as they migrate through the mainstem. This monitoring program will also provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change considerations and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management, which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the influx of insect and amphipod prey to the mainstem migration corridor for juvenile MCR steelhead. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[302] of all MCR steelhead populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

[302] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give

2.8.3.1.8 Tributary Habitat

The Action Agencies stated that habitat improvement investments for MCR steelhead would continue as a component of BPA's Fish and Wildlife program, but their proposed action did not include specific commitments for this DPS (BPA et al. 2020).

If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could provide benefits to the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for MCR steelhead as part of this proposed action, or proposed them in a manner that would allow us to meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential projects in our jeopardy analysis.

2.8.3.1.9 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail in the site-specific biological opinions referenced therein (see Section 2.8.2.2). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.8.3.1.10 Predation Management

<u>Avian Predators</u>

Avian Predators in the Lower Columbia River Estuary

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested

larger numbers of juvenile steelhead opportunities to move into wetland habitats for food and refuge from predators. Moreover, the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the MCR steelhead DPS.

from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions will continue current levels of predation at this colony, which, in the case of Caspian terns, is an average annual reduction of 7 percent compared to the pre-colony management period. However, ocean conditions, including compensatory effects such as the number and behavior of predators and competition for prey, will determine whether this reduction in tern predation influences adult returns. Although there appears to have been a moderate decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 7.5 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, we expect that cormorant predation in the estuary may be an increasingly important source of mortality for MCR steelhead.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none are proposed at this time.

Avian Predators in the Hydrosystem Reach

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia River dam. At each dam, bird numbers will be monitored, birds foraging in dam tailraces will be hazed (including, in some circumstances, lethal reinforcement), and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway, powerhouse discharge, and juvenile bypass outfall areas, will also continue. If proven biologically and cost effective, the Corps will deploy laser systems to haze birds foraging near bypass outfalls. Upgrades to existing systems, including bird wires and McNary Dam, will be coordinated through the FPOM and included in the annual Fish Passage Plans. We expect that these measures will continue to reduce predation on juvenile MCR steelhead, although Zorich et al. (2012) were unable to quantify the amount of protection.

The Action Agencies propose to continue to address Caspian tern predation on lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015 but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. These measures are likely to preclude use of Crescent Island by Caspian terns. Reclamation will continue passive and active dissuasion efforts for Caspian terns on Goose Island. They have coordinated the timing and duration of the proposed work with USFWS to ensure it will be effective in maintaining the management objectives of fewer than 40 breeding pairs at this site, consistent with the IAPMP. This ongoing suite of colony management actions is likely to continue current levels of predation by terns in the interior Columbia River basin. Although we do not have species-specific data for MCR steelhead, this is likely to be a small to moderate improvement for juveniles from the Yakima and Walla Walla MPGs compared to the pre-colony management period.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the hydrosystem reach are warranted. However, we do not consider the effects of new actions because none are proposed at this time.

John Day Reservoir—Spring Operations to Reduce Predation Rates by Caspian Terns

The Action Agencies propose to hold the elevation of John Day Reservoir at 264.5 to 266.5 feet from April 10 to June 1 or no later than June 15 each year, or as feasible based on river flows, to inundate bare sand habitat and deter Caspian terns from nesting in the Blalock Islands Complex. Because foraging effort and predation rates increase once chicks hatch, the Action Agencies will begin to increase the reservoir's elevation before Caspian terns initiate nesting (i.e., operations may begin earlier than April 10). The Action Agencies will consider bird observations along with the run timing of juvenile steelhead to determine the dates each year. At the conclusion of this operation, the draft to operating range (262.5 to 264.5 feet) will be completed within 4 days. In general, 95 percent of the juvenile steelhead migration passes John Day Dam by June 1 (DART 2020m).

The timing of this operation is based on the expectation that Caspian terns will begin colonizing exposed habitat and start courtship and nest building within days to weeks of returning the reservoir to the 262.5- to 264.5-foot range. In general, chicks hatch about 27 days after eggs are laid, at which point energetic demands and fish consumption rates increase substantially. Thus, we expect that inundating bare sand habitat until most yearling steelhead pass John Day Dam will reduce predation rates on individuals from the MCR steelhead DPS.

Fish Predators

The NPMP's Sport Reward Fishery, or a similar removal effort, will continue as part of the proposed action. The current fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the numbers of steelhead, including some from the MCR steelhead DPS, handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy) will be no more than 100 adults and 600 juveniles per year. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams and will conduct test fisheries at additional dam projects on the Snake River as described in the proposed action (BPA et al. 2020). This may help to further reduce predation on juvenile salmonids, but the likelihood of the program being implemented at additional Columbia River dams (which would produce greater benefits for MCR steelhead) is not reasonably certain to occur. We estimate that no more than 10 adult and 20 juvenile steelhead, including some from the MCR steelhead DPS, will be caught in the Dam Angling Program per year.

These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including MCR steelhead.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea lion exclusion devices at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and Bonneville will continue to support land- and water-based harassment efforts to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually. Hazing and dissuasion shall be supportive of pinniped removal efforts and cover the periods from March 31 through May 31 and August 15 through October 31. The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management Coordination Team and the Sea Lion Task Force, to address changing circumstances as they relate to sea lion harassment efforts and predation monitoring at Bonneville Dam. These ongoing measures, in conjunction with removal efforts, are expected to maintain or reduce current levels of sea lion predation on MCR steelhead in the Bonneville tailrace, which is currently estimated at 1.6 percent (Tidwell et al. 2020). If pinnipeds are observed at The Dalles Dam, the Corps may respond with hazing at adult fish ladder entrances.

2.8.3.1.11 Fish Status Monitoring Actions

Adult Overshoot

A large proportion of MCR steelhead from the John Day and Umatilla MPGs do not enter their natal tributaries during the summer migration period, likely because of elevated water temperatures and low flow. Based on PIT detections, a large group of these fish overshoot McNary Dam, presumably to hold until conditions in natal tributaries improve. Many of these fish do not attempt to migrate back downstream through McNary Dam until after the prescribed spill has ended in August, and a smaller portion do not attempt downstream migration until after the juvenile bypass system has shut down in mid-November, which leaves the turbines (lowest survival route for adult steelhead) as the only available passage route for many of these fish.

The 2008 biological opinion required that the Action Agencies investigate methods of estimating overshoot fallback and develop operations or structural improvements, if prudent, to improve survival for adult steelhead that fall back over mainstem dams. Research has demonstrated the spillway weir is the most effective and safe route to pass adult steelhead at McNary Dam, and confirmed that the turbine unit had significantly lower survival, presumably caused by blade strike and shear forces (Normandeau et al. 2014).

Keefer et al. (2007) found that overshoot-related winter fallback mortality may be relatively high at dams closest to home tributaries, such as for John Day River fish at McNary Dam. They estimated the relative survival impacts of winter (November to April) fallbacks by steelhead at lower Columbia and lower Snake River dams and found that fallback in March and November has the largest negative effect on survival. They concluded that providing alternative fallback routes at dams during winter can improve overall survival of steelhead. Richins and Skalski (2018) found evidence that successful arrival at spawning tributaries was reduced for steelhead that overshot dams, and provide evidence that spill during the steelhead spawning migration period should improve homing to natal tributaries.

As described in the proposed action (BPA et al. 2020), the Action Agencies plan to continue to fund and support an overshoot steelhead evaluation at McNary Dam and potentially other dams with the intent of developing an operation for future passage of overshoot steelhead and kelts. A limited volume of Temporary Spillway Weir (TSW) spill (8 to 11 kcfs) is currently being used at 24 hours per week in conjunction with hydroacoustic and PIT tag monitoring to evaluate passage timing and migration success (and to assess potential impacts to non-targeted stocks of fish). The results of this study will help to develop a future operation at McNary Dam and at other dams to support a high rate of adult MCR steelhead migration success without creating unnecessary losses to power revenue by effectively syncing the timing of a long-term operation and providing an effective volume of water. So although no improvement in adult survival from this research can be assumed at this time, survival rates for adult MCR steelhead from many populations could be improved as a result of future actions stemming from this research.

2.8.3.1.12 Research, Monitoring, and Evaluation Activities

The Action Agencies’ RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP’s boat electrofishing efforts are reduced to zero when juvenile and adult MCR steelhead are likely to be present in shallow shoreline areas, an unknown portion of the DPS will continue to be stunned, harmed or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this DPS that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[303]

The level of RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of MCR steelhead will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS:
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - 10 hatchery and 12,000 natural-origin juveniles will be handled.
  - One hatchery and 240 natural-origin juveniles will die.
- Activities associated with all other RME programs:
  - 500 hatchery and 700 natural-origin adults will be handled.
  - 18 hatchery and 18 natural-origin adults will die.
  - 1,000 hatchery and 10,000 natural-origin juveniles will be handled.
  - 10 hatchery and 100 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program is expected to affect, on average, up to 4 percent (3.9 percent) of the natural-origin adult run (recent, 5-year average at Bonneville Dam) and up to 5.4 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to less than 1 percent of estimated DPS abundance); the effects on

[303] Ongoing and future discussions are expected to lead to substantial reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations (including facilities modifications and mitigation actions) the effects of the RME programs on abundance are acceptable and warranted.

2.8.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small reduction in obstructions for juvenile inriver migrants at the four mainstem dams in the lower Columbia River. Adults migrating during periods of gas cap spill are likely to experience a small increase in obstructions due to an increased rate of involuntary fallback over the spillway. Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.8-16.

Table 2.8-16. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the MCR steelhead DPS.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning and rearing sites	The proposed action will not change the functioning of spawning and juvenile rearing sites designated as critical habitat for MCR steelhead.
Freshwater migration corridors	*Effects in the migration corridors apply to all populations of MCR steelhead:* Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. Proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not change the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and early summer and warmer temperatures in the late summer and fall. Adult MCR steelhead entering the lower Columbia River during summer and fall will be exposed to the warmer mainstem temperatures (degraded water quality in the migration corridor). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of proposed operations. Continued reduced sediment discharge and turbidity, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the Columbia River and the plume, which may reduce "natural cover" in the migration corridor for all populations. This effect is partly due to

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	the existence of the dams, which is in the environmental baseline, and partly an effect of proposed operations. Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill at the CRS run-of-river projects in the lower Columbia River. The effect on water quality in terms of an increase in the incidence of GBT is likely to be very small. The Corps will continue to protect water quality by using best management practices to minimize accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. The flexible spring operation to 125 percent TDG will increase obstructions in the adult migration corridor by a very small amount by increasing the risk of fallback over project spillways and by degrading tailrace conditions at John Day Dam for steelhead that overwinter in the lower Columbia River and migrate upstream in the spring. The flexible spring operation to 125 percent TDG will reduce obstructions in the juvenile migration corridor by a small amount by increasing the likelihood of spillway passage. However, the increased spill levels that are likely to degrade tailrace conditions at John Day Dam (obstructions in the migration corridor), are also likely to increase the risk of bird and fish predation. Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions for juveniles and adults by a small amount because some will pass downstream or fall back through a turbine unit. Continued small increases in obstructions for adult steelhead during routine outages of fishways or turbine units. Very small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities (e.g., to upgrade turbines at Ice Harbor, McNary, and John Day Dams and for a major repair such as the jetty and retaining wall at Little Goose Dam). Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Long-term effect of turbine upgrades will be reduced obstructions (improved turbine survival). Repairing the jetty at Little Goose Dam will also reduce obstructions for adults at that project. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Increased operating range for John Day Reservoir will reduce the risk of avian predation by a moderate amount while increasing juvenile travel times by a small amount (moderate reduction in excessive predation and slight increase in obstructions).

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	Continued implementation of the Action Agencies' bird, fish, and pinniped predator management programs will continue recent levels of predation risk in the juvenile and adult migration corridors.
Estuarine areas	*Effects in estuarine areas apply to all populations of MCR steelhead:* Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels and juvenile and adult forage. This will increase access to prey for yearling steelhead that remain in the mainstem. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.8.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.8.1), Environmental Baseline (Section 2.8.2), and Effects of the Action (Section 2.8.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. They address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation), a variety of stream and riparian habitat projects; watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas; instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including MCR steelhead.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired) and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.8.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.2.3) to the environmental baseline (Section 2.2.2) and the cumulative effects (Section 2.2.4), taking into account the status of the species and critical habitat (Section 2.2.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.8.5.1 Species

The MCR steelhead DPS includes all naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) to and including the Yakima River. The DPS comprises 20 historical populations (three of which are extirpated) grouped into four MPGs: Yakima River (four populations), Umatilla River (three extant populations), John Day River (five populations), and Cascade Eastern Slope Tributaries (five extant populations). The most recent 5-year status review indicated there have been improvements in the viability ratings of some populations in the DPS, but the DPS as a whole is not currently meeting the viability criteria. Twelve of the 17 extant populations are ranked as maintained, viable, or highly viable. The John Day River MPG is least at risk (all five populations are rated maintained, viable, or highly viable), and the other MPGs all have at least one population rated at high risk. For the great majority of populations, recent adult returns (2014 to 2018) have been substantially (30 to 60 percent) below average 2009-2013 returns. This downturn is associated with a marine heatwave and its lingering effects, which likely contributed to substantially lower ocean survival rates of juvenile steelhead. Some of these negative effects had subsided by spring 2018 and expectations for marine survival were mixed for 2019 outmigrants.

MPGs from this DPS are affected by upstream and downstream passage through between one and four lower Columbia River dams: Yakima River MPG populations migrate past all four lower Columbia River dams; Umatilla River MPG populations migrate past three or four dams; John Day MPG populations migrate past three dams; and Cascades Easter Slope Tributaries MPG populations migrate past one or two dams. Each MPG has at least two populations rated at maintained or higher. Conditions for MCR steelhead populations have generally improved in the mainstem Columbia River because of the installation and operation of surface passage routes, 24-hour spill, improved spill patterns, and improvements to the juvenile bypass systems at the mainstem dams. McNary to Bonneville survival rates for hatchery and natural-origin Snake River steelhead (a surrogate for MCR steelhead) vary substantially, but have averaged about 76 percent the past 10 years (2010 and 2019) (Zabel 2019 and Widener et al. 2020). Populations from MPGs passing fewer lower Columbia River dams should have higher survival rates.

The juvenile survival rates from McNary Dam to Bonneville Dam include all sources of mortality, even those that are not caused by the past or proposed operation and maintenance of the CRS. For instance, regardless of the operational or configurational choices made for the hydrosystem, some predation and other natural mortality of juvenile MCR steelhead would occur during their migration. In addition, juvenile survival is influenced by past and present alterations of shoreline habitat, among other stressors, unrelated to the effects of operating the hydrosystem; many of those effects will continue into the future. We are unable to differentiate the proportion of the losses that result from the operation and maintenance of the mainstem dams rather than to the existence of the dams, but we know that the mortality attributable to operations and maintenance is less than the losses captured in the overall survival estimates. As discussed further below, some also hypothesize that passage through juvenile bypass systems and turbines causes latent mortality, which would not be captured in the direct survival estimates.

Adult survival rates (adjusted to account for reported harvest and typical straying rates), include "natural" mortality as well as any mortality associated with injuries incurred from predators. Adult survival rates for MCR steelhead from the Yakima River MPG (which pass four dams) are relatively high, averaging nearly 96 percent from Bonneville and McNary Dam. Survival rates for populations from the Umatilla and John Day MPGs (which pass three dams) should be similar, though many of these fish “overshoot” McNary and other, upstream dams, then “fallback” through the dams in the fall (after temperatures are cooler) or following spring in order to ascend their natal tributaries when temperatures are more favorable. A study to assess the efficacy of operating a surface passage route to provide safe and effective downstream passage for MCR steelhead at McNary Dam began in the fall of 2019. This study is expected to identify operational measures that could be used at McNary and other dams to provide effective downstream passage for adult steelhead that overshoot their natal streams. Adults from the Cascade Eastern Slope Tributaries should have even higher survival rates as they only pass 1 or 2 dams to reach their natal streams. Few adult MCR steelhead should be affected by increased spring spill levels because they predominantly migrate in the summer and fall. For those few that pass lower Columbia River dams in the spring, although increased spring spill levels at some of the dams are expected to slightly increase adult fallback rates, associated mortalities should be offset by adults falling back through spillbays (which have higher survival rates than juvenile bypass systems or turbine units).

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Overall, scheduled maintenance activities are expected to continue to negatively affect small numbers of adult MCR steelhead annually. A few adults will die as a result of these activities each year, but these losses are not likely to measurably affect adult reach survival estimates. Very few juveniles are likely to be affected by these activities because they are not typically migrating during the period of time when these activities are scheduled. Non-routine and unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the inseason adaptive management process, the impact of these events is likely small and should not measurably affect juvenile reach survival estimates. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative spill or turbine unit priorities) will likely minimize these impacts.

The proposed spring spill levels would implement a program of voluntary fish passage spill with the highest spill volumes ever implemented. This will increase juvenile exposure to higher TDG levels; however, it is unlikely that spilling up to 125 percent TDG for 16 hours per day at mainstem dams will result in any substantial, negative impacts to juvenile survival (or adult passage) because there are sufficient data and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). The potential for negative effects from increased TDG may be greater for juvenile steelhead than for other species because they tend to migrate higher in the water column; however, they typically occur deeper than 1 to 2 meters from the surface so depth compensation would still ameliorate effects of high TDG. In 2020, implementation of spring spill up to 125 percent TDG did not cause GBT symptoms at levels of concern. In addition, there is sufficient monitoring and in-season management flexibility to address any negative consequences (e.g., high GBT symptoms or adult passage blockages). The proposed 125 percent flexible spill operation could slightly improve direct juvenile survival rates through the four lower Columbia River mainstem projects (with the possible exception of Bonneville Dam, where survival rates could decrease slightly, and at The Dalles Dam, which will maintain spill levels of 40 percent), although the COMPASS modeling comparing the Preferred Alternative to the No Action Alternative suggested there would be no benefit (USACE et. al. 2020). The CSS model predicts more substantial increases in juvenile survival, and further hypothesizes that fewer powerhouse passage events (as a result of higher spill levels and higher proportions of juveniles passing the projects via spillbays) will increase adult returns of the Snake River populations by about 28 percent. If this is the case, to the extent that MCR steelhead experience latent mortality associated with dams, higher spill levels would be expected to increase adult returns accordingly, but likely no more than half (14 percent) that hypothesized by the CSS for SRB steelhead (28 percent), because they pass through no more than half as many Federal projects (Yakima River MPG). If these predictions are realized, they would represent a near-term improvement in productivity and abundance for the Yakima River MPG and, over time, would somewhat reduce the severity of expected declines in abundance and productivity caused by warming climate and deteriorating ocean conditions. The potential benefit for the other MPGs (Umatilla, John Day, and Cascade Eastern Slope Tributaries) in this ESU should be substantially lower.

Nearly all historical habitat for the MCR steelhead DPS has been modified extensively by human activities. Generally, the ability of tributary habitats in the middle Columbia River to support the viability of this DPS is limited by one or more of the following factors: 1) impaired fish passage (including tributary dams), 2) reduced stream complexity and channel structure, 3) excess fine sediment, 4) elevated summer water temperature, 5) diminished stream flow during critical periods, 6) reduced floodplain connectivity and function, and 7) degraded riparian condition.

Many habitat improvement actions have been funded and implemented by the Action Agencies and other Federal, tribal, state, local, and private entities throughout the DPS. These include barrier removals (i.e., Condit dam, Powerdale Dam, and irrigation diversions) and other tributary habitat improvements (e.g., protecting and improving instream flow, improving habitat complexity, improving riparian area condition, and reducing fish entrainment). These actions have been targeted toward addressing limiting factors, and NMFS has determined that these actions have improved, and will continue to improve, habitat in the targeted populations as these projects mature, and that fish population abundance, productivity, spatial structure, and diversity will respond positively. The benefits of some of these actions will continue to accrue over several decades. At the same time, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

While tributary habitat conditions in the MCR steelhead DPS are likely improving in some areas as a result of habitat improvement actions and improved land use practices, in general, they are still degraded and continue to negatively affect MCR steelhead abundance, productivity, spatial structure, and diversity, and additional tributary habitat improvements are needed to achieve recovery goals. The Action Agencies stated that habitat improvement investments for MCR steelhead would continue as a component of BPA's Fish and Wildlife program, but their proposed action did not include specific commitments for this DPS (BPA et al. 2020), and therefore, we are not considering the benefits of potential projects in our jeopardy analysis.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving UCR steelhead abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas— actions that are likely to provide measurable improvements to VSP metrics (abundance / productivity and life-history diversity) for all populations in this DPS. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan, the Double-crested Cormorant Management Plan, and the IAPMP, as well as hazing at the mainstem dams. For MCR steelhead, we expect that management of tern colonies throughout the basin is reducing mortality by a small to moderate amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Increased numbers of native and nonnative fishes that prey on steelhead smolts are also present in the hydrosystem reach. Increasing the John Day reservoir elevation in the spring should control impacts from the Blalock Islands tern colony. The NPMP and dam angling program are expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested cormorant Management Plan, these programs will maintain current (reduced) levels of predation, which is creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on MCR steelhead in the lower Columbia River and estuary has increased slightly with recent increases in the abundance of steller sea lions in the summer and fall. Losses in the Bonneville tailrace remain relatively low, averaging a little more than 1 percent. Sea lion predation downstream of Bonneville Dam, including the estuary, continues to negatively affect the productivity and abundance of UCR steelhead.

The past effect of artificial production programs has largely been to increase abundance and help preserve genetic resources—especially true for safety net or conservation hatchery programs during times of low abundance. However, these programs have also posed risks to natural productivity and genetic diversity. Hatchery strays may pose a significant risk to Eastside and Westside Deschutes and John Day populations, and are also of concern for Umatilla and Walla Walla populations. The proportion of Snake River steelhead straying into the John Day MPG populations has been trending downward, potentially as a result of reduced juvenile transport rates and modifications to SRB steelhead hatchery management practices. Many out-of-basin steelhead entering the Deschutes River are likely seeking a thermal refuge and will eventually migrate to their natal streams, lessening the threat of genetic introgression. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of MCR steelhead. Additionally, the kelt reconditioning program initiated by the Yakama Confederated Tribes should improve VSP parameters for the Yakima River MPG populations, especially in years when abundance is low and releases can represent a substantial fraction of the female spawners.

The largest harvest-related effects on MCR steelhead result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery, and determined that the harvest rate should continue to average around 2 percent (maximum of about 4 percent, including an estimated 10 percent mortality of wild-released fish).

As described in Section 2.8.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area considered for MCR steelhead are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect MCR steelhead in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of MCR steelhead as high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change.

Summer-run adults could potentially respond temporally to changing environmental conditions by migrating and spawning later in time. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or flood events). Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in streams. Juveniles would be exposed to higher summer temperatures in tributaries, though juvenile migrants could potentially respond temporally by migrating earlier in the spring. Though the quality of information is mixed, sensitivity in the marine stage is likely high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur. These climate change consequences are not caused by the proposed action. In simple terms, even if the adult abundance declines as predicted under climate change, which will make recovery of this DPS more challenging, it will have declined no more so as a result of the proposed action.

The proposed action—the future operation and maintenance of the CRS (including upper Columbia River operations to better protect resident species and Dworshak Dam winter operations to reduce TDG in the lower Clearwater River)—will have little overall effect on the seasonal hydrograph or seasonal temperatures compared to recent conditions. The seasonal hydrograph will continue to be altered, generally increasing flows in the fall and winter and reducing flows in the spring. Seasonal water temperatures will also continue to be altered, with delayed warming in the spring, delayed cooling in the fall, and reduced daily temperature variability. These effects to river conditions likely adversely affect the survival of MCR steelhead, but to an extent not readily quantified based upon the best available information.

Other operations (e.g., operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, increasing the John Day reservoir operating range during the spring to reduce avian predation, etc.) are, collectively, expected to have small negative effects, especially on juvenile migrants, but these effects should not measurably alter survival estimates between Lower Granite and McNary Dam.

The proposed action includes many measures to reduce the adverse effects of the passage impediments caused by the existence of the CRS, including juvenile fish passage spill, operation of juvenile bypass systems, attraction flows for adults, and the operation of adult fish ladders. In addition to these measures, if the flexible spring spill operation increases adult returns by up to 14 percent (half that hypothesized by the CSS for SRB steelhead), MCR steelhead would experience a near-term improvement in productivity and adult abundance over current conditions.

Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this DPS (e.g., dam passage survival, population productivity, and degraded estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.).

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity and likely affects marine survival (to an unknown extent) through latent mortality. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., estuary habitat, predation, etc.). Evidence shows that these actions have resulted in improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The recent downturn in adult abundance (2014 to 2019) is primarily the result of recent poor ocean conditions and not of altered tributary and mainstem habitat conditions. The proposed action carries forward structural and operational improvements since 2008 and improves upon them. Potential improvements resulting from reduced latent mortality are possible, and ecosystem functions should continue to increase in estuary habitats where improvement actions occur.

Climate change is a substantial threat to MCR steelhead, especially during the marine rearing phase of their life cycle. The proposed action should not exacerbate either the scope and/or severity of those impacts.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of MCR steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of MCR steelhead.

2.8.5.2 Critical Habitat

NMFS designated critical habitat for MCR steelhead to include all estuarine areas and river reaches of the mainstem Columbia River from its mouth upstream to its confluence with the Yakima River, and many of its tributaries to this reach beginning with the Deschutes River, Oregon, and Wind River, Washington. Across subbasins with PBFs for MCR steelhead in the Interior Columbia Recovery Domain, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web); reduced water quality; and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use and water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

Measures taken through the individual and combined efforts of Federal, tribal, state, local, and private entities, including the Action Agencies, in the decades since critical habitat was designated have improved the functioning of spawning and rearing area PBFs. These include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. However, more improvements will be needed before many areas function at a level that supports the recovery of MCR steelhead.

The environmental baseline also includes a broad range of past and present actions and activities, including effects of the hydrosystem that have affected the conservation value of critical habitat in freshwater migration corridors for MCR steelhead. Some of these past effects of CRS operations will continue under the proposed action: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and passage delays (obstructions in the juvenile migration corridor). These factors have increased the likelihood of excessive predation on juvenile and adult MCR steelhead and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The proposed action carries forward structural and operational improvements since 2008 that address these effects on PBFs and in some cases, improves upon them. The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors.

The Action Agencies also have reduced effects of their operations on travel time and survival for juvenile salmonid migrants by increasing levels of spring spill. We expect the additional flexible spring spill to 125 percent TDG to reduce water quality in the migration corridor by a small amount while having a small positive effect on obstructions at CRS projects in the lower Columbia River through increased spillway passage. In low runoff years, increased spill could degrade tailrace conditions for juvenile migrants at John Day Dam, increasing the risk of bird and fish predation. However, there is sufficient flexibility through the in-season management process to identify and remedy any negative effects through modified spill patterns. Most adult MCR steelhead enter the Columbia River after the spring spill period ends on June 20 so that there will be only very small negative effects on water quality and obstructions in the migration corridor.

Operating turbines above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction for adults (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions by a small amount because some adults will fall back or juveniles will move downstream through turbines.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors.

In summary, the proposed action is not likely to further limit water quantity or water quality or to increase obstructions in the juvenile or adult migration corridors by a meaningful amount. In addition, if the CSS hypothesis regarding latent mortality is correct, the flexible spill program could improve the functioning of the juvenile migration corridor to a greater extent than indicated by the likely effects on obstructions described above.

Increasing the elevation of John Day Reservoir to cover nesting areas on the Blalock Islands will limit the risk of predation by Caspian terns by delaying nesting until about 95 percent of steelhead outmigrants have passed McNary Dam. The Action Agencies also will continue to implement measures to reduce pinniped predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the hydrosystem and the estuary, and the predation management programs for Caspian terns on the interior plateau and for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will maintain the levels of predation in the juvenile and adult migration corridors that were observed in recent years, although cormorant predation rates may increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the estuary, many of these funded through the CRS program. The Action Agencies propose to continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling steelhead migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of MCR steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of MCR steelhead designated critical habitat.

2.8.6 Conclusion

After reviewing and analyzing the current status of MCR steelhead and its critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of MCR steelhead or destroy or adversely modify its designated critical habitat.

2.9 Columbia River (CR) Chum Salmon

This section applies the analytical framework described in Section 2.1 to the CR chum salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the CR chum salmon ESU or destroy or adversely modify its critical habitat.

2.9.1 Rangewide Status of the Species and Critical Habitat

The status of the CR chum salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.9.1.1 Status of the Species

2.9.1.1.1 Background

On March 25, 1999, NMFS listed the CR chum salmon ESU as a threatened species (64 FR 14508). The threatened status was reaffirmed on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that this ESU should retain its threatened status (81 FR 33468). Critical habitat was designated on September 2, 2005 (70 FR 52630). The summary that follows describes the status of CR chum salmon. More information can be found in the recovery plan (NMFS 2013b) and most recent status review for this species (NMFS 2016i).[304]

The CR chum salmon ESU includes all naturally spawned populations of chum salmon in the Columbia River and its tributaries in Oregon and Washington (Figure 2.9-1).[305] The ESU consists of 17 historical populations in three distinct ecological regions: Coast, Cascade, and

[304] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

[305] The historical upstream boundary for chum salmon is generally considered to have been Celilo Falls, which historically was located approximately where The Dalles Dam is now located (NMFS 2013b).

Gorge. Each of these three ecological regions is considered an MPG.[306] The ESU also includes two artificial propagation programs (70 FR 37160).[307]

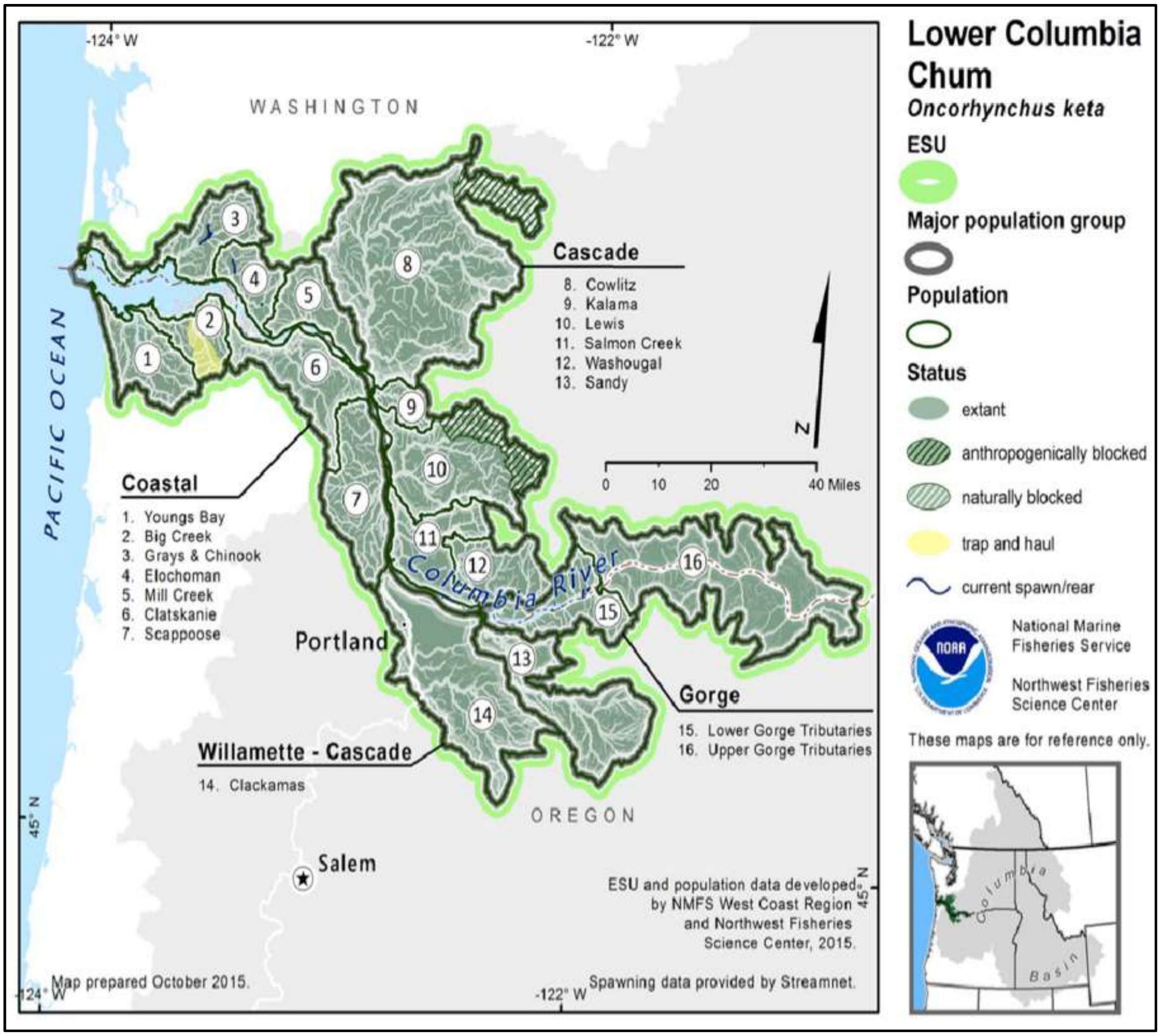

Figure 2.9-1. Map illustrating CR chum salmon ESU's populations and major population groups.

2.9.1.1.2 Life History and Factors for Decline

Historically, CR chum salmon were abundant and widely distributed. They spawned in the mainstem Columbia River and the lower reaches of most lower Columbia River tributaries. The

[306] The W/LC TRT used the term "strata" to refer to these population groupings, which are significant in identifying delisting criteria. The strata are analogous to the "major population groups" defined by the ICTRT. For consistency, we use the term "major population group" throughout this opinion.

[307] The Grays River Program and the Washougal River Hatchery/Duncan Creek Program in Washington. In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including CR Chum salmon (81 FR 72759). The proposed change for hatchery program inclusion in this ESU was to add the Big Creek Hatchery Program (Oregon). We expect to publish the final revisions in 2020. For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c).

historical upstream boundary for chum salmon is generally considered to have been Celilo Falls, which was located approximately where The Dalles Dam is now located, although there are some reports of chum salmon spawning as far up as the Walla Walla and Umatilla Rivers (NMFS 2013b). Chum salmon spawn in the mainstem and in low-gradient, low-elevation reaches and side channels (LCFRB 2010, ODFW 2010). They enter freshwater close to the time of spawning, and their spawning sites are typically associated with areas of upwelling water. Adult chum salmon are virtually all fall-run fish, entering freshwater from mid-October through November and spawning from early November to late December (LCFRB 2010). There is evidence that a summer-run chum salmon population returned historically to the Cowlitz River, and fish displaying this life history are occasionally observed there (Myers et al. 2006, Ford 2011).

Chum salmon fry are capable of adapting to seawater soon after emergence from gravel (LCFRB 2010) and usually spend weeks or months in estuaries (NMFS 2011, 2013b). Their small size at emigration is thought to make them susceptible to predation from both birds and fish during this life stage, and shallow, protected habitats such as salt marshes, tidal creeks, and intertidal flats serve as significant rearing areas for juvenile chum salmon during estuarine residency (LCFRB 2010). Access to these habitats has been impaired by agricultural and residential land use, particularly modification via dikes, levees, bank stabilization, and tide gates, but also by flow alterations caused by mainstem dams.

CR chum salmon runs once numbered in the hundreds of thousands (in some years more than 500,000 chum salmon were harvested in commercial fisheries), but had begun to decline by the early 1950s (Johnson et al. 2012), primarily as a result of habitat degradation and high harvest rates. While harvest rates were drastically curtailed in the 1950s, the ESU continues to be affected by loss and degradation of spawning and rearing habitat and perhaps by the legacy effects of historical harvest. In addition, mainstem hydropower dams have impaired access and inundated historical spawning habitat for one population, and had downstream flow effects on habitat in the estuary. Together, these factors contributed to declines such that at the time of listing, total natural-origin abundance for the ESU was probably a few thousand fish per year, and most historical populations were either at very high extinction risk or extirpated, or nearly so (NMFS 2013b, 64 FR 14508).

2.9.1.1.3 Recovery Plan

The ESA recovery plan for CR chum salmon (NMFS 2013b) includes delisting criteria for the ESU, along with identification of factors currently limiting its recovery, and management actions necessary for recovery. The biological delisting criteria are based on recommendations by the Willamette-Lower Columbia Technical Recovery Team (W/LC TRT).[308] They are hierarchical in nature, with ESU-level criteria based on the status of natural-origin CR chum salmon assessed at

[308] The recovery plan also includes "threats criteria" for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

the population level. Population-level assessments are based on an evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the ESU will require sufficient improvement in its abundance, productivity, spatial structure, and diversity.

2.9.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within an ESU based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the W/LC TRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low extinction risk. For CR chum salmon, recovery requires improving all three MPGs to a high probability of persistence or a probability of persistence consistent with their historical condition.

NMFS' most recent status review found that the CR chum ESU was relatively unchanged in status from previous reviews (NMFS 2016i). While improvements in the status of some populations were observed, most remained at high to very high extinction risk, with very low abundances, and the ESU overall remained at moderate to high extinction risk. Most populations will require very large improvements to reach their recovery goals (NWFSC 2015, NMFS 2016i).

In the most recent status review, the Grays River population, in the Coast MPG, was considered to be on an improving trend and at moderate, if not lower, extinction risk. The other six populations in this MPG were considered to be at very high extinction risk, and some perhaps functionally extirpated. In the Cascade MPG, two spawning aggregates discovered in the early 2000s in the mainstem Columbia River just upstream of the I-205 Bridge are considered part of the Washougal population, and the abundance trend for this spawning aggregation was found to be stable and potentially slightly positive in the most recent status review. The other five populations in the Cascade MPG were considered at very high extinction risk, with critically low abundances. In the Gorge MPG, the Lower Gorge population was considered viable, and its abundance as of the most recent status review was, on average, somewhat improved since the previous status review; however, ocean conditions were likely responsible for this increase, and the overall trend since 2000 was found to be negative (NWFSC 2015). Spawning in the Upper Gorge population (above Bonneville) was thought to be very limited due to the inundation of historical spawning areas by Bonneville Reservoir; however, small numbers of chum salmon do migrate past Bonneville Dam in most years, and chum fry are observed at the Bonneville Dam juvenile sampling facility (NWFSC 2015).

Table 2.9-1 lists the MPGs and populations in this ESU and summarizes their abundance/productivity, spatial structure, diversity, and overall population risk status at the time of the most recent status review; it also summarizes their target risk status for delisting (NMFS 2013b, 2016i; NWFSC 2015).

Table 2.9-1. CR chum salmon population-level risk for abundance/productivity (A/P), spatial structure, diversity, overall extinction risk as of the most recent status review (NWFSC 2015, NMFS 2016i), and recovery plan target status (NMFS 2013b). Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH). The populations that spawn upstream of Bonneville Dam are highlighted in gray. * = no data.

MPG		Population	A/P Risk Rating	Spatial Structure Risk Rating	Diversity Risk Rating	Overall Extinction Risk Rating	Recovery Plan Target Extinction Risk Rating
Ecological Subregion	**Run Timing**						
Coast Range	**Fall**	Youngs Bay (OR)	*	*	*	VH	VH
		Grays/Chinook Rivers (WA)	VL	M	L	M	VL
		Big Creek (OR)	*	*	*	VH	VH
		Elochoman/Skamokawa creeks (WA)	VH	L	H	VH	L
		Clatskanie River (OR)	*	*	*	VH	L
		Mill, Germany, and Abernathy creeks (WA)	VH	L	H	VH	L
		Scappoose River (OR)	*	*	*	VH	L
Cascade Range	**Summer**	Cowlitz River (WA)	VH	H	H	VH	M
	Fall	Cowlitz (WA)	VH	L	H	VH	M
		Kalama River (WA)	VH	L	H	VH	M
		Lewis River (WA)	VH	L	H	VH	L
		Salmon Creek (WA)	VH	H	H	VH	VH
		Clackamas (OR)	*	*	*	VH	M
		Sandy (OR)	*	*	*	VH	L
		Washougal (WA)	VH	L	H	VH	VL
Columbia Gorge	**Fall**	Lower Gorge (WA, OR)	VL	L	VL	L	VL
		Upper Gorge (WA, OR)	VH	H	H	VH	M

2.9.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the CR chum salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed.

For CR chum salmon, the pervasive loss of spawning, incubation, and rearing habitat is a primary limiting factor. Chum spawning habitats (upwelling areas of clean gravel beds in mainstem and side-channel portions of low-gradient reaches above tidewater) have been practically eliminated in most systems as a result of past and current land uses. Similarly, access to the estuary habitats in which juvenile chum salmon spend considerable time rearing has been impaired by agricultural and residential land use, particularly modification via dikes, levees, bank stabilization, and tide gates, but also by flow alterations caused by mainstem dams. These alterations impair sediment routing, influence habitat-forming processes, reduce access to peripheral habitats, and change the dynamics of the Columbia River estuarine food web (NMFS 2013b).

For the Upper Gorge population, which spawns above Bonneville Dam, the dam has impeded passage and inundated historical spawning habitat. For the Lower Gorge population, hydrosystem operations have the potential to limit access to spawning and incubation habitat in the Bonneville tailrace by dewatering redds before emergence. To avoid this, the Action Agencies provide flows at Bonneville Dam to support chum spawning, incubation, and migration (NMFS 2013b). In almost all years since such flows have been implemented, the Action Agencies have been able to fully support chum spawning, incubation, and migration below Bonneville Dam; however, in 2 years out of the last 21, other objectives have impaired the ability to fully support chum spawning, incubation, and migration (see Section 2.9.2.1 below for more detail).

While high historical harvest rates of chum salmon contributed to their decline, harvest rates have been drastically reduced and harvest mortality is no longer considered a limiting factor for CR chum salmon. Land development, especially in the low gradient reaches that chum salmon prefer, will continue to be a threat to most populations due to projected increases in the population of the greater Vancouver/Portland area and the lower Columbia River overall (Metro 2014). This continued habitat degradation, in combination with the potential effects of climate change, will present a continuing strong negative influence.

The recovery plan for CR chum salmon identifies ESU- and MPG-level biological recovery criteria,[309] and within each MPG, it also identifies specific population-level goals consistent with the MPG-level criteria (NMFS 2013b). Achieving recovery will require improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts (see discussion below in Sections 2.9.1.2, 2.9.2.1, and 2.9.2.2), and reestablishing chum salmon populations where they may have been extirpated.

2.9.1.1.6 Information on Status of the Species since the 2016 Status Review

We do not have updated dam counts for this species comparable to those discussed in prior sections for interior basin salmon and steelhead, because almost all CR chum salmon spawning takes place below Bonneville Dam. The best scientific and commercial data available indicate recent increasing trends in the abundance of both natural-origin and total spawners when

[309] The ESU-level criterion is that each MPG that historically existed must have a high probability of persistence or have a probability of persistence consistent with its historical condition. The recovery plan also contains criteria for determining whether an MPG has met that standard, based on the status of the individual populations in the MPG (NMFS 2013b).

compared to the 2009 to 2013 period (Table 2.9-2), with the exception of the Upper Gorge Tributaries population, which decreased in abundance.[310]

Table 2.9-2. 5-year geometric mean of natural-origin spawner counts for CR chum salmon. Number in parenthesis is the 5-year geometric mean of total spawner counts. “% change” is a comparison between the two most recent 5-year periods (2014-2018 compared to 2009-2013). "NA" means not available. An “*” indicates that, at the time of drafting this opinion, data for the Upper Gorge Tributaries population only were available through 2017. No data for chum salmon were available for 2019. Source: Williams (2020e).

MPG	Population	1999-2003	2004-2008	2009-2013	2014-2018	% Change
Coast	Grays and Chinook Rivers	NA	4898 (5246)	5767 (6058)	8884 (9525)	54 (57)
Cascade	Washougal River	NA	925 (931)	2084 (2097)	2641 (2658)	27 (27)
Columbia Gorge	Lower Gorge Tributaries	NA	978 (995)	1707 (1722)	3540 (3563)	107 (107)
	Upper Gorge Tributaries	48	141	80	68*	-15

Since 2016, observations of coastal ocean conditions indicate that recent outmigrant year classes have experienced below-average ocean survival during a marine heatwave and its lingering effects (Werner et al. 2017). The relationship between ocean conditions and chum salmon survival is an area of active investigation. A preliminary model suggested increased adult returns in response to the same environmental indicators that predict higher Chinook and coho salmon returns, but failed to predict the substantial adult returns in 2016 and significantly under-predicted returns in 2017 and 2018 (Hillson 2020, Homel 2020). The ocean survival of chum salmon was above average in 2016 through 2018, potentially due to their unique consumption of the types of gelatinous organisms (jellies, salps, larvaceans) that were abundant during the recent warm ocean conditions (Brodeur et al. 2019, Morgan et al. 2019).

NMFS will evaluate the implications for extinction risk of more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.9-2.

2.9.1.2 Status of Critical Habitat

NMFS (2005b) designated critical habitat for CR chum salmon to include all estuarine areas and river reaches from the mouth of the Columbia River upstream to the confluence with the White

[310] The upcoming 2021 status review is expected to include population-level adult returns through 2019, and the 5-year periods used for calculating geomeans will shift forward (i.e., the last period will include 2015 to 2019). Shifting 2014 to the preceding 5-year grouping could reduce the magnitude of the positive percent change for some populations.

Salmon River (50 CFR 226.212(l)). Critical habitat for CR chum salmon encompasses six subbasins in Oregon and Washington containing 18 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2013b) and have some, or high, potential for improvement. Similar to the discussion above regarding effects on the species, the status of critical habitat is likely to be affected by climate change, with predicted rising temperatures and alterations in stream flow patterns. Improved access to spawning and rearing habitat, and habitat restoration efforts, will help reduce those effects on critical habitat.

Of 18 designated HUC5[311] watersheds, NMFS (2005b) gave 17 a high rating and one a medium rating for their value to the conservation (i.e., recovery) of the species. The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution to the species it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b), as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting

[311] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country. A HUC5 is a five-unit (5 two-digit numbers) code. Examples are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the Wenatchee Basin, Washington.

juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.

- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.
- Nearshore marine areas free of obstruction, with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case of freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Critical habitat has been designated for CR chum salmon in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. NMFS considers the estuary to have a high conservation value because it connects every population with the ocean and is used by rearing and migrating juveniles and by migrating adults. In addition, some adult CR chum salmon spawn in the mainstem in areas influenced by discharge (inundation, TDG levels) at Bonneville Dam.

Human activities since the late 1800s have altered the form and function of the Columbia River estuary, reducing the quantity and quality of its PBFs. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained this environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in the mainstem navigation channel; and causeways have been constructed that restrict the position of tributary confluences.

In addition, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban use. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from upstream reservoirs have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of the historical variability in mainstem flows in the lower river through storage and release operations at upstream reservoirs may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has eliminated shallow-water habitats, which were seasonally important rearing areas and refugia for juvenile salmonids, particularly for small subyearling migrants such as CR chum salmon. Disconnecting the tidal river from its floodplain also prevented delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The remainder of the area designated as critical habitat is in the reach between the tailrace of Bonneville Dam and the White Salmon River confluence. The Action Agencies' efforts to provide a tailwater elevation that supports chum salmon spawning just below Bonneville Dam during late fall and winter and then supports incubation and emergence into spring is described in Section 2.9.2.1. The Action Agencies have been successfully balanced refill at the upper basin storage projects with spring flows that support the water quantity and substrate needed by chum salmon for spawning and incubation, as well as the water quantity needs of other ESUs and DPSs, in 19 of the last 21 years. NMFS (2005b) designated critical habitat in three occupied HUC5 watersheds in the Middle Columbia/Hood subbasin within the reservoir reach upstream of the dam and rated each as having a high conservation value. The reservoir itself is part of the high value rearing and migration corridor connecting upstream watersheds with downstream reaches and the ocean, although its conservation value is negatively affected by passage conditions at Bonneville Dam. Most of the historical spawning habitat in the lower reaches of the tributaries to the reservoir is now inundated, but some spawning successful spawning takes place in these streams as evidenced by increasing numbers of adult chum salmon in the fish ladders in recent years.

The effect of these conditions as a whole is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs and thus the conservation value of critical habitat for CR chum salmon within the action area are discussed in more detail in the Environmental Baseline section, below.

2.9.1.3 Climate Change Implications for CR Chum Salmon and Critical Habitat

One factor affecting the rangewide status of CR chum salmon and aquatic habitat is climate change. The USGCRP[312] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[313] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

Likely changes in temperature, precipitation, and wind patterns (as well as sea-level rise in the lower estuary) have implications for survival and recovery of CR chum salmon in both their freshwater, estuarine, and marine habitats and the PBFs of their critical habitat. While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (ISAB 2007). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1 to 4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure,

[312] http://www.globalchange.gov

[313] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

and coastal wetlands and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, certain management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations). Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends on both the characteristics of individual populations and the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable; therefore, maintaining or promoting the diversity currently found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the CR chum salmon ESU.

Climate change would affect CR chum salmon and critical habitat through physical and chemical changes to their habitats (e.g., increased water temperature, decreased ocean pH, changes in the timing and volume of stream flow). The physical and chemical changes may result in biological impacts such as, but not limited to, reduced ocean survival, changes in growth and development, and changes in run timing and spawning timing (Link et al. 2015). These biological changes can lead to changes in species productivity and abundance, distribution, food web structure, community structure, invasive species impacts, and biodiversity and resilience (Link et al. 2015).

Crozier et al. (2019) assessed CR chum salmon as having moderate vulnerability to the effects of climate change based on an analysis of the ESU's sensitivity (moderate) and exposure (moderate). Further, this ESU was determined to have moderate adaptive capacity (Crozier et al. 2019).[314] Given the late-autumn return and spawn timing of CR chum salmon, temperatures under climate change scenarios may not be limiting for adult prespawn survival or early life history. Furthermore, the preference for some of these chum salmon to spawn in areas with groundwater seeps provides relatively constant incubation conditions and would moderate somewhat the effect of changes in temperature and precipitation. Sea-level changes could impact the habitat of chum salmon that spawn in the lowermost reaches of Columbia River tributaries by pushing water farther onto the floodplain, as well as allowing saltwater to move farther upstream along the bottom of the lower river.

Estuary and ocean temperature conditions may change more rapidly than incubation conditions, especially at groundwater seeps, and such changes could leave juvenile migrants "out-of-sync" with nursery conditions. Accordingly, this species' sensitivity to cumulative life-cycle effects was ranked as moderate. The small size of juvenile emergent chum salmon migrating to the

[314] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results.

estuary makes them especially vulnerable to changing conditions in the lower river and estuary as well. For example, the quantity, type, and timing of zooplankton that juvenile chum salmon feed upon while rearing in the Columbia River estuary and nearshore environs may be dramatically altered under climate change, especially due to ocean acidification. It is during this early ocean entry period that chum salmon are most vulnerable to alterations in their environment.

2.9.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area; the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For CR chum salmon, we focus our description of the environmental baseline on the portion of the action area where juveniles and adults are most exposed to the effects of the proposed action. We also include tributary habitat upstream of occupied habitat because these habitats, while not influenced by the proposed action, have affected conditions and most historical spawning populations within the action area.

To determine the upstream extent of CR chum salmon, and thus exposure to effects of the proposed action, we reviewed and analyzed CR chum salmon passage observations from 2013 to 2018 at Bonneville Dam and The Dalles Dam. An average of 119 adults were observed at Bonneville Dam during this period, ranging from 21 fish in 2017 to 180 fish in 2018. During the 6 years where data were available, either zero or four fish overshot The Dalles Dam. Therefore, the area where CR chum salmon experience the effects of the proposed action is the Columbia River from the tailrace of John Day Dam to the plume,[315] including tributary confluences in this reach to the extent that they are affected by flow management and estuary habitat mitigation actions.[316]

[315] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

[316] At this time, the Action Agencies have not proposed habitat mitigation actions in tributaries with CR chum habitat; see Section 2.9.3.1.4 for more information.

2.9.2.1 Mainstem Habitat

On the mainstem of the Snake and Columbia Rivers, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.9-2). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

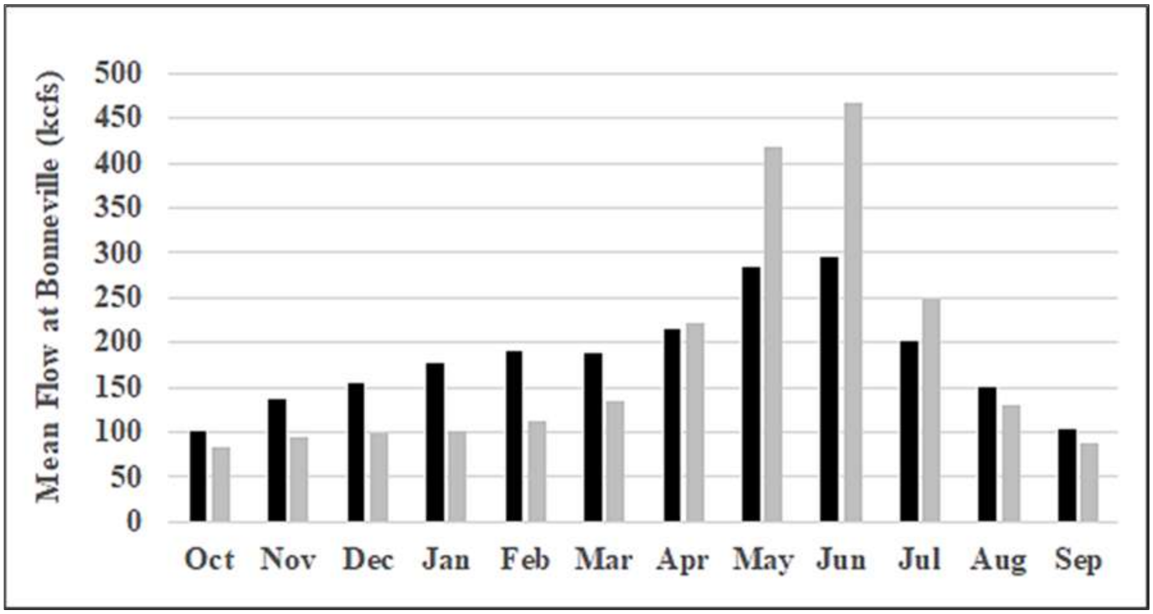

Figure 2.9-2. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[317] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year (Table 2.9-3).This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Reduced spring and summer flows have increased travel times during outmigration for juvenile salmonids and, combined with the construction of dikes and

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[317] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

levees, have reduced access to high-quality estuarine habitats from May through July. However most chum salmon fry (approximately 80 percent) emerge and migrate downstream before mid-April, and chum typically spend only days to weeks in the estuary, minimizing the effects of the decrease in flows from May to July.

Table 2.9-3. Seasonal flow objectives and planning dates for the mainstem Columbia and Lower Snake Rivers. NA indicates that there is not a flow objective for the season at these projects.

Location	Spring		Summer	
	Dates	Objective (kcfs)	Dates	Objective (kcfs)
Snake River at Lower Granite Dam	4/03 to 6/20	85 to 100[a]	6/21 to 8/31	50 to 55[a]
Columbia River at McNary Dam	4/10 to 6/30	220 to 260[a]	7/01 to 8/31	200
Columbia River at Priest Rapids Dam	4/10 to 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125 to 160[b]	NA	NA

[a] Objective varies based on actual and forecasted water conditions.

[b] Objective varies according to water volume forecasts and is for chum salmon (spawning period is approximately November 1 through December and protection flow objectives are based on redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

CR chum salmon spawn in the mainstem at the Ives/Pierce Island complex in the Bonneville tailrace. For this large spawning aggregation, which is part of the Lower Gorge chum salmon population, access to spawning and incubation habitat at higher elevations around the islands and the Washington shoreline can be limited by hydrosystem operations. These operations include flow management at upper basin reservoirs and load following for electricity production at Bonneville Dam. The Action Agencies provide a tailwater elevation at Bonneville Dam each year that supports chum spawning during late fall and winter and then supports incubation and emergence in the Ives Island complex into spring. This typically requires flow augmentation from storage reservoirs before reliable flow forecast information becomes available. If the tailwater elevation level selected during the spawning season is too high (i.e., requires deeper reservoir drafts), there is an increased risk of missing the April 10 refill objective at Grand Coulee Dam, which has the potential to reduce spring flow augmentation for juvenile outmigrants from the interior ESUs and DPSs. Conversely, if flows must be reduced during the chum salmon incubation period to target refill, there is the risk of dewatering those redds. When this conflict arises, the TMT discusses how to balance refill at the storage projects with spring flows that benefit multiple ESUs, which generally have priority over maintaining the chum tailwater elevations (BPA et al. 2018a). In almost all years since chum flows have been implemented, the Action Agencies have been able to fully support chum spawning, incubation, and migration below Bonneville Dam; in 2 years out of 21 years, however, other objectives have impaired the ability to fully support chum spawning, incubation, and migration.

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.9.2.2 Passage Survival

Only one population in this ESU is affected by passage conditions at Bonneville Dam: Upper Gorge chum salmon. There are no studies of downstream passage survival for juvenile CR chum salmon. The survival of downstream migrants is likely to have increased over the past two decades due to several structural and operational improvements including: 1) the construction of the Bonneville PH2 Corner Collector, 2) operation of the Ice and Trash Sluiceway, 3) construction of the juvenile bypass system at Powerhouse 2, and 4) increased levels of controlled spill. When in operation, these measures are likely to reduce passage time and the frequency of turbine passage for juvenile chum salmon at Bonneville Dam (Ploskey et al. 2012). However, not all of these protections are in place for the entire juvenile chum salmon outmigration and as a result, early migrants may encounter more delay and mortality than later migrants. From 2002 to 2016, chum salmon fry emerged from redds below the dam during early February to May, but on average, 62 percent of the catch in fry traps below Bonneville Dam (range: 21 to 86 percent) was captured during March (Hillson et al. 2017). Assuming the emergence timing from upstream spawning areas is similar, a substantial proportion of juvenile chum salmon are likely to migrate past Bonneville Dam before voluntary spill starts in April and for some smolts, even before the Bonneville Powerhouse 2 corner collector begins operation in March. Therefore, it is likely that not all outmigrants from the Upper Gorge chum salmon population will experience these improved passage conditions. There are no empirical estimates of passage survival for juvenile chum salmon, and because these outmigrants are much smaller, we are unable to use subyearling fall Chinook salmon, for example, as a surrogate.

Adult chum salmon counts in the ladders at Bonneville Dam ranged from 17 in 2000 to 414 in 2003, averaging 107 adults per year. The most recent 10-year average (2010 to 2019) is 127 adults (DART 2020k), which is similar to the average for the earlier period. However, adult chum counts at Bonneville Dam rose to 180 in 2018 and 316 in 2019. NMFS (2008a) estimated that the adult passage survival rate for chum salmon at Bonneville Dam was similar to that of Snake River fall Chinook salmon, which are present during the same time period (about 96.9 percent). Passage survival estimates are based on general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

2.9.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult CR chum salmon is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of CR chum salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead survival is a concern; because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer and fall water temperatures).
- Increased temperatures of tributaries due to water managed for irrigated agriculture, and due to grazing and logging.
- Point-source thermal discharges from cities and industries.
- Climate change.

Temperatures in the middle Columbia River are affected by Grand Coulee Dam, completed in 1942. Thermal inertia from the large mass of water in the reservoir (total storage capacity of 9.6 million acre-feet, active capacity of about 5.2 million acre-feet) results in delayed warming in the spring (cooler temperatures) and delayed cooling in the late summer and fall (warmer temperatures).

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period from 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the run-of-river dams and found three notable differences between the current and the unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed “thermal inertia.”

Dams in the middle and lower reaches of the Columbia River likely have similar effects.

These hydrosystem effects (which stem from both upstream storage projects and run-of-river mainstem projects) continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broadscale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

The main effect of these changes on CR chum is that cooler water temperatures in the spring can delay the accrual of heat for incubating eggs and delay emergence and emigration of fry. Delayed emergence can have an interactive effect with exposure to elevated TDG (discussed below) for fry that emigrate after spring spill operations commence on April 10 in the lower Columbia River.

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with Federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam, except The Dalles Dam. Biological monitoring (smolts sampled from the juvenile bypass systems at many mainstem dams) shows that the incidence of observable GBT symptoms remains between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[318] Under recent operations (2008 to 2019), exposure to high TDG levels exceeding state standards was restricted to lack of market or lack of turbine capacity

[318] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

spill events associated with high flow conditions and/or lack of load, which have most often occurred between mid-May and mid-June, which has little potential to affect CR chum salmon fry because in years with average water temperature about 80 percent of the fry have emerged and emigrated by May 1.

Adult chum salmon are in the vicinity of the Bonneville Dam tailrace during November through December each year, and therefore are not likely to be exposed to elevated levels of TDG. Bonneville tailwater elevation is maintained between 11.5 and 13 feet through spawning if reservoir elevations (indicative of available storage) and climate forecasts indicate this operation will be feasible.

Eggs are present in the mainstem spawning area near the tailrace (the Ives/Pierce Island area) during winter, and fry are present in the bypass system at Bonneville and the mainstem spawning area through May. The Action Agencies, as coordinated through the TMT, minimize the risk of GBT to incubating eggs and alevins (yolk sac fry) by maintaining a tailwater elevation that provides adequate depth to provide emerging fry protection from excess TDG during the April and May spring spill period.

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

2.9.2.3.1 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death.

The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of CR chum salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[319] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[320] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances and the toxicity varies among different types of oils and

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[319] The Lower Columbia River and Lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[320] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river.

greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.9.2.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adults that are migrating past the dams or within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Few (<1 percent) adult CR chum and very few juvenile CR chum salmon have been affected by these maintenance activities because scheduled maintenance activities are typically scheduled to avoid the adult and juvenile migration period and alternative ladders and juvenile passage routes are available.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small. The impact of unscheduled maintenance on juvenile and adult CR chum salmon has likely resulted in some ladder delay and some increased TDG exposure, however, powerhouse capacity is not typically exceeded at Bonneville Dam during the chum migration periods, and measures to reduce these impacts such as rapidly restoring FPP criteria and providing alternative routes or attraction water have minimized the impacts.

2.9.2.5 Tributary Habitat

CR chum salmon primarily use habitat in the lower ends of tributaries (e.g., within or just above the range of tidal influence in tributaries below Bonneville Dam) (NMFS 2013b). The pervasive loss of some critical spawning and incubation habitat is a primary limiting factor for CR chum salmon, which typically spawn in upwelling areas of clean gravel beds. These habitats have been eliminated in many systems through a combination of channel alteration and sedimentation that is attributable largely to past and current land uses, including forest management, agriculture, rural residential uses, urban development, and gravel extraction. Low-elevation stream reaches have been affected by extensive channelization, diking, wetland conversion, stream clearing, and gravel extraction (NMFS 2013b). Impaired watershed processes continue to limit chum salmon habitat through effects on floodplain and wetland habitat conditions and connectivity, riparian conditions, and channel structure. For example, high densities of unimproved rural roads increase fine sediment concentrations in tributary streams that settle out in low gradient areas, covering spawning gravels and increasing turbidity. Highway and transportation corridors run parallel to the Columbia River shoreline on both sides of the river, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes, especially for the Upper and Lower Gorge chum salmon populations (NMFS 2013b, 2016i).

In addition, the Upper Gorge population spawns in the lower ends of tributaries that were inundated by Bonneville Reservoir when the dam was completed in 1938 (NMFS 2013b). Although current spawning areas have not been identified in Bonneville Reservoir, small numbers of adults and juveniles are counted in the adult fish ladders and juvenile bypass system each year, indicating that some spawning habitat is still available.

The WDFW added two sections of spawning and incubation habitat to Skamokawa Creek in 2018, which will contribute to the spawning success of this population in the Coastal MPG in future years.

2.9.2.6 Estuary Habitat

Chum salmon fry are commonly found in wetland channels in the lower Columbia River estuary floodplain in March through May. Thus, the estuary provides important rearing habitat for CR chum salmon, as well as the migration corridor between spawning and rearing areas and the ocean. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with hydrosystem flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for subyearling salmon and reduced the production of wetland macrodetritus that supports salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review, have improved access and connectivity to floodplain habitat (NMFS 2016i). From 2007 through 2019, restoration sponsors implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents a more than 2.5 percent net increase in the connectivity of habitats used extensively by chum salmon fry (Johnson et al. 2018). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

As discussed in Section 2.9.2.3, habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, the levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, and they are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life history types.

2.9.2.7 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect natural populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

There are three CR chum salmon hatchery programs: the Grays River and Washougal River Hatchery/Duncan Creek programs in Washington and the Big Creek Hatchery program in Oregon. The Grays River and Washougal River programs are considered to be part of the ESU.[321] The two Washington programs, funded by BPA, are designed to supplement the natural spawning populations, while the Mitchell Act funded program at Big Creek Hatchery is designed to support reintroduction efforts into LCR tributaries in Oregon. For the reintroduction program, the demographic concerns outweigh any risk posed by hatchery-induced selection, so no

[321] In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including CR Chum salmon (81 FR 72759). The proposed change for hatchery program inclusion in this ESU was to add the Big Creek Hatchery Program (Oregon). We expect to publish the final revisions in 2020.

standards for pHOS or PNI are being applied at this time. However, to continue to be consistent with recovery, the program will in time develop a local stock and move to PNI-based management. At this time, the benefits of the hatchery program still outweigh the risks (NMFS 2017i). The current low productivity of the chum salmon in the LCR warrants the continued supplementation of the target populations with hatchery fish.

2.9.2.8 Recent Ocean and Lower River Harvest

There is no direct harvest of CR chum salmon, though chum salmon have been harvested incidentally in fisheries targeting other species. Commercial harvesters in the lower Columbia River annually harvested an average of 58 chum salmon from 2000 to 2013. In October of 2013, the sale and possession of chum salmon in all fisheries was prohibited (WDFW and ODFW 2018). All recreational fisheries have been closed since 1995.

Impacts in the recreational fishery (from non-retention mortalities, i.e., catch-and-release mortality) are expected to be near zero because chum salmon enter the Columbia River near the end of October, which coincides with a period of declining angler effort (TAC 2017). Under current harvest management, the incidental harvest rate is limited to no more than 5.0 percent; however, the actual incidental harvest rates have averaged 0.3 percent from 2008 to 2018, and the long-term total impact rate on CR chum salmon between 2018 and 2027 is expected to average 1.6 percent per year (TAC 2017). There are no impacts expected in treaty tribal fisheries above Bonneville Dam (TAC 2017).

2.9.2.9 Predation

2.9.2.9.1 Avian Predation

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river’s estuary and plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge to the lower river, especially during spring, contributes to reduced turbidity, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

There are no estimates of avian predation rates for CR chum salmon using PIT-tag detections. Lyons et al. (2014) identified only one chum salmon from 451 foregut samples of cormorants collected near East Sand Island. Juvenile chum salmon were a negligible component of the diet of Caspian terns nesting on Rice Island (Collis et al. 2002).

2.9.2.9.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). No chum salmon were reported killed or handled in the NPMP's Sport Reward Fishery from 2015 to 2019.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019. Anglers did not catch any chum salmon from 2015 through 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). During these same years, the Dam Angling Program has removed an average of 2,781 northern pikeminnow from The Dalles Dam tailrace alone, but since the CR chum salmon ESU only includes populations found below The Dalles Dam, this program is not likely to provide much benefit to juvenile CR chum salmon.

Juvenile salmonids are also consumed by nonnative fishes, including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these fish, both in the lower Columbia River and Bonneville Reservoir may incrementally improve juvenile chum salmon survival.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile chum salmon, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. In 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP. These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal remains unclear. However, NPMP fishery evaluation demonstrates that the Sport

Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the chum salmon that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity for CR chum salmon. As such, it likely continues to benefit the ESU.

2.9.2.9.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions, Steller sea lions, and harbor seals all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace Bonneville Dam. ODFW counted the number of individual California sea lions hauling out in the Columbia River mouth at the East Mooring Basin in Astoria, Oregon, from 1997 to 2017. Individual pinniped counts at East Mooring Basin have steadily increased since the inception of the observation program with rapid increases within the last decade (Wright 2018). Pinniped counts at the East Mooring Basin during the chum salmon migration (November and December) have also increased in recent years, but have been variable and have not increased to the degree they have increased in the spring (Table 2.9-4).

Table 2.9-4. Maximum monthly counts of California sea lions at Astoria, Oregon, East Mooring Basin, 2008–2017 (counts ended in June 2017, so more recent data are not available; NA) (Wright 2018).

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg
2008	40	56	67	126	162	46	6	191	213	204	273	157	128
2009	27	42	84	118	173	45	38	346	376	241	89	84	139
2010	58	93	136	229	216	157	29	316	356	265	98	54	167
2011	19	42	77	155	242	126	11	302	246	85	159	106	131
2012	20	27	82	240	201	92	19	212	187	147	91	21	112
2013	37	149	595	739	722	153	8	368	377	208	182	100	303
2014	237	586	1420	1295	793	90	32	423	492	369	94	126	496
2015	260	1564	2340	2056	1234	623	37	394	1318	459	84	208	881
2016	788	2144	3834	1212	1077	620	3	291	1004	878	235	246	1028
2017	1498	2345	808	1131	1204	573	NA	NA	NA	NA	NA	NA	1260

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg
Avg	298	705	944	730	602	253	20	316	508	317	145	122	413

Increasing pinniped abundance in the Columbia River estuary has resulted in an increased loss of adult spring Chinook salmon in recent years (Rub et al. 2019). The magnitude of pinniped predation on chum salmon is likely lower than on spring Chinook salmon primarily because far fewer overall pinnipeds are present when chum salmon migrate. However, Steller sea lion abundance in the lower Columbia River has been increasing, and this species has commonly overwintered at Bonneville Dam during the chum spawning period in recent years (Tidwell et al. 2020). Abundance of Steller sea lions in the Bonneville tailrace during the fall and winter monitoring period averaged 14.5 individuals per day. Above average presence of Steller sea lion (Figure 2.9-3) and predation on adult salmonids during the chum salmon spawning period have been recorded in the Bonneville tailrace (Tidwell et al. 2018), however, minimal chum predation has been observed at Bonneville Dam (Tidwell et al. 2020). Chum salmon spawn just downstream of the Bonneville tailrace, but it is currently unknown how many chum salmon are being consumed by Steller sea lions at spawning locations. Pinniped predation on individual adult chum salmon at the Ives Island spawning grounds has been observed anecdotally (Hillson 2018), but the magnitude of the predation events has not been estimated.

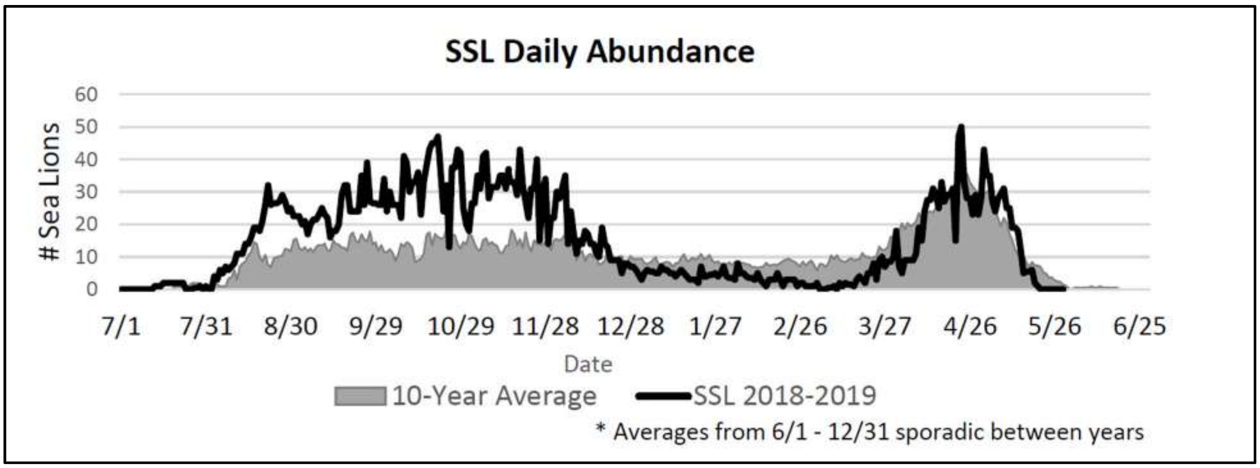

Figure 2.9-3. Comparison of estimated abundance of each pinniped species at Bonneville Dam between the 10-year running average and the current year (USACE 2019).

Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019, respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation

Prevention Act was signed into law in December 2018. It reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the mainstem of the Columbia River between RM 112 and McNary Dam (RM 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

2.9.2.10 Research, Monitoring, and Evaluation Activities

The primary effects of the past and present CRS-related RME on CR chum salmon are those associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were CR chum. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the CR chum ESU by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of CR chum salmon that have been handled (or have died) each year using the average annual take reported for 2016 to 2019. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of CR chum salmon associated with the Smolt Monitoring Program and the CSS were as follows:
    - 21 natural-origin juveniles were handled
    - zero natural-origin juveniles died.
- Average annual estimates for CR chum salmon handling and mortality for all other RME programs were as follows:
    - Zero hatchery or natural-origin adults were handled.
    - Zero hatchery or natural-origin adults died.
    - 76 hatchery and 687,061 natural-origin juveniles were handled.
    - One hatchery and 3,696 natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) of CR chum salmon associated with these elements of the RME program has, on average, affected zero percent of the natural-origin, adult (recent, 5-year average) run (arriving at mouth of the Columbia River) and 10 percent of naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities that negatively affects CR chum salmon.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the ESU level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.9.2.11 Critical Habitat

The condition of CR chum salmon critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized here in Table 2.9-5. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for CR chum salmon production have been weakened. Conditions in the portion of the hydrosystem designated as critical habitat (i.e., the mainstem Columbia River below the confluence of the White Salmon River) were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for CR chum salmon have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.9-5. Physical and biological features (PBFs) of designated critical habitat for CR chum salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development.	Loss of upwelling areas of clean gravel beds through channel alteration and sedimentation (forest management, agriculture, rural residential uses, urban development, and gravel extraction) has reduced the availability of freshwater spawning sites for all populations. Loss of wetland and side channel connectivity (channel manipulations, diking, wetland conversion, stream clearing, gravel extraction) has reduced the quality of freshwater spawning sites for all populations. Excessive sediment in spawning gravel (unimproved roads, forest and agricultural practices in upstream

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		watersheds) has reduced the quality of freshwater spawning sites for all populations. Some improvement in riparian, channel, and floodplain conditions in the lower ends of the tributaries where large dams have been removed (e.g., White Salmon, Hood, and Sandy Rivers) has improved the quality of freshwater spawning sites for some populations. Inundation of some chum salmon spawning sites in the lower ends of tributaries under Bonneville Reservoir (hydrosystem development) has reduced the availability of freshwater spawning sites for the Upper Gorge population. Past operations of the CRS periodically dewatered the mainstem spawning area, and access to local tributaries, in the tailrace of Bonneville Dam during spawning and incubation (hydrosystem development and operations). In the last two decades, the Action Agencies have implemented flow measures to provide a minimum tailwater elevation. Except in years with low water storage in upstream reservoirs, this has ensured adequate water quantity and substrate for spawning and through the time of emergence for this portion of the lower Gorge population. Observations of increased pinniped predation of adults in mainstem spawning areas below Bonneville Dam (increased levels of predation). Despite concerns about effects on spawning sites for the Lower Gorge population, we consider this type of predation, which is not associated with a man-made structure, to be natural (i.e., not “excessive”).
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, and natural cover.	Loss of wetland and side channel connectivity (channel manipulations, diking, wetland conversion, stream clearing, gravel extraction) has reduced the quality of freshwater rearing sites for all populations. Excessive sediment in streambed (unimproved roads, forest and agricultural practices in upstream watersheds) has reduced the quality of freshwater rearing sites for all populations.
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover.	Alteration of the seasonal flow regime in the lower Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies’ ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		average to high flow years and a moderate negative effect in lower flow years for all populations. Alteration of the seasonal mainstem temperature regime in the lower Columbia River due to thermal inertial associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in late summer and fall (hydrosystem development and operations).[1] This has negatively affected the functioning of water quality in the adult migration corridor for adult CR chum salmon from all populations. Reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (hydrosystem development) may have reduced "natural cover" in the migration corridor for all populations. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining) affects all populations. The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable lubricants" where feasible. Increased exposure of juveniles to TDG (water quality) in Bonneville Reservoir and at least 35 miles below Bonneville Dam during involuntary and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor for late migrating juvenile chum salmon from the Upper Gorge and Lower Gorge Tributaries populations. The incidence of adverse effects (GBT in juveniles is assumed to have been small in recent years. Adult chum salmon migrate in the fall and are not exposed to elevated TDG associated with spring spill. Increased obstructions (delay and mortality) of juveniles and adults from the Upper Gorge population and for some adults from the Lower Gorge population that ascend (and fallback) at Bonneville Dam (hydrosystem development and operation). Reduced obstructions for juveniles migrating downstream when surface passage routes and increased spill operations begin in March. Small increases in obstructions for adult chum salmon during routine outages associated with scheduled maintenance or non-routine maintenance of fish

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		facilities or turbine units (delay and mortality of adults migrating past Bonneville Dam). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Small increase in obstructions for juvenile chum salmon because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include repair of the spillway apron at Bonneville Dam and overhauling the juvenile bypass system. Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for fish predation on juveniles in the tailrace of Bonneville Dam (excessive predation) for Gorge populations. Pinniped predation on adults is addressed by the use of sea lion excluder devices at the fishway entrances at Bonneville Dam.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, and juvenile and adult forage.	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production and the quantity and quality of estuarine rearing areas for all populations. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce refuge and prey for chum salmon by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.
Nearshore marine areas[2]	Free of obstruction and excessive predation with water quality, quantity, and forage.	Concerns about increased pinniped predation and adequate forage. Reduced quality of nearshore marine areas.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.9.2.12 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of CR chum salmon, including recent biological opinions issued for CR chum salmon and key emergent or ongoing habitat concerns (NMFS 2016i). From January 2015 through May 22, 2020, we completed 272 formal consultations that addressed effects to CR chum salmon.[322] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat and riparian conditions, and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPAs were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in

[322] PCTS data query July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.9.2.13 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of CR chum salmon populations. Hydrosystem effects include changes in the seasonal hydrograph, which combined with diking, filling, and bank hardening have disconnected floodplain rearing habitat from the mainstem; changes in the seasonal temperature regime; access to spawning habitat in the tailrace of Bonneville Dam; and obstructions in the juvenile and adult migration corridors at Bonneville Dam. Since the time of listing, the Action Agencies have stabilized flows below Bonneville Dam for the spawning period and through emergence except in years with extremely low stored water in upper basin reservoirs. Recent improvements in passage conditions at Bonneville Dam, and the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, are positive signs, but other stressors are likely to continue. NMFS (2016i) identified freshwater habitat conditions in the lower ends of tributaries as negatively influencing spawning and early rearing success and contributing to the overall low productivity of the ESU. Land development in these low-gradient reaches will continue to be a threat to most chum salmon populations, due to projected increases in the population of the greater Portland/Vancouver area and the lower Columbia River overall. These factors, in combination with the potential effects of climate change, are likely to continue to negatively affect CR chum salmon populations.

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for CR chum salmon as described above. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in recent years to improve the functioning of some of these critical habitat PBFs. For example, surface passage structures and spill operations have reduced obstructions for juvenile chum salmon at Bonneville Dam. Projects to reconnect the lower river floodplain to the mainstem are improving the functioning of areas used for growth and development. However, the factors described above continue to have negative effects on these PBFs.

2.9.3 Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system, system operations (including operations for fish passage at mainstem Snake and Columbia River dams), maintenance; structural measures to benefit Pacific lamprey, non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.9.3.1 Effects to Species

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams. The intent of flexible spill operations is to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem.[323] The operation is designed to improve the survival of spring-migrating juvenile salmon and steelhead from the interior Columbia River basin through the hydrosystem, but will also affect late-migrating juvenile chum salmon.

Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG spill ("gas cap spill") for a minimum of 16 hours per day and under lower spill levels ("performance standard spill") for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill at all hours. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs maximum spill constraint) for 16 hours per day with 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan, unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in performance standard spill periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spring spill levels with exceptions at each

[323] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

project are defined in Table 2.9-6. By the time summer spill operations commence at the Columbia River projects on June 14, CR chum will have already migrated to the estuary.

Table 2.9-6. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March, decreased flows from May through August, and little change in flows in April and September) described in the Environmental Baseline section will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.

- Potential drafting of Dworshak Reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in all project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce high TDG events associated with spill in the winter, which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. The proportional effect on flow is higher in the lower Snake River than in the lower Columbia River due to its smaller flow volume. Nonetheless these flow changes do transfer into the lower Columbia River and have the potential to affect CR chum in the lower Columbia River. However, the proposed operation is expected to occur in only the highest flow years.

The proposed changes in reservoir operations will not affect spring or summer flows relative to current operations during dry water years, and will affect summer flows only minimally during average to wet water years. The associated effects on CR chum salmon smolts should not change from recent conditions by a meaningful amount, and there will be no associated effects on CR chum salmon adults.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July, when chum salmon are not present. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.9-4).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia

River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially. The associated effects on CR chum salmon smolts should not change from recent conditions by a meaningful amount, and there will be no associated effects on CR chum salmon adults.

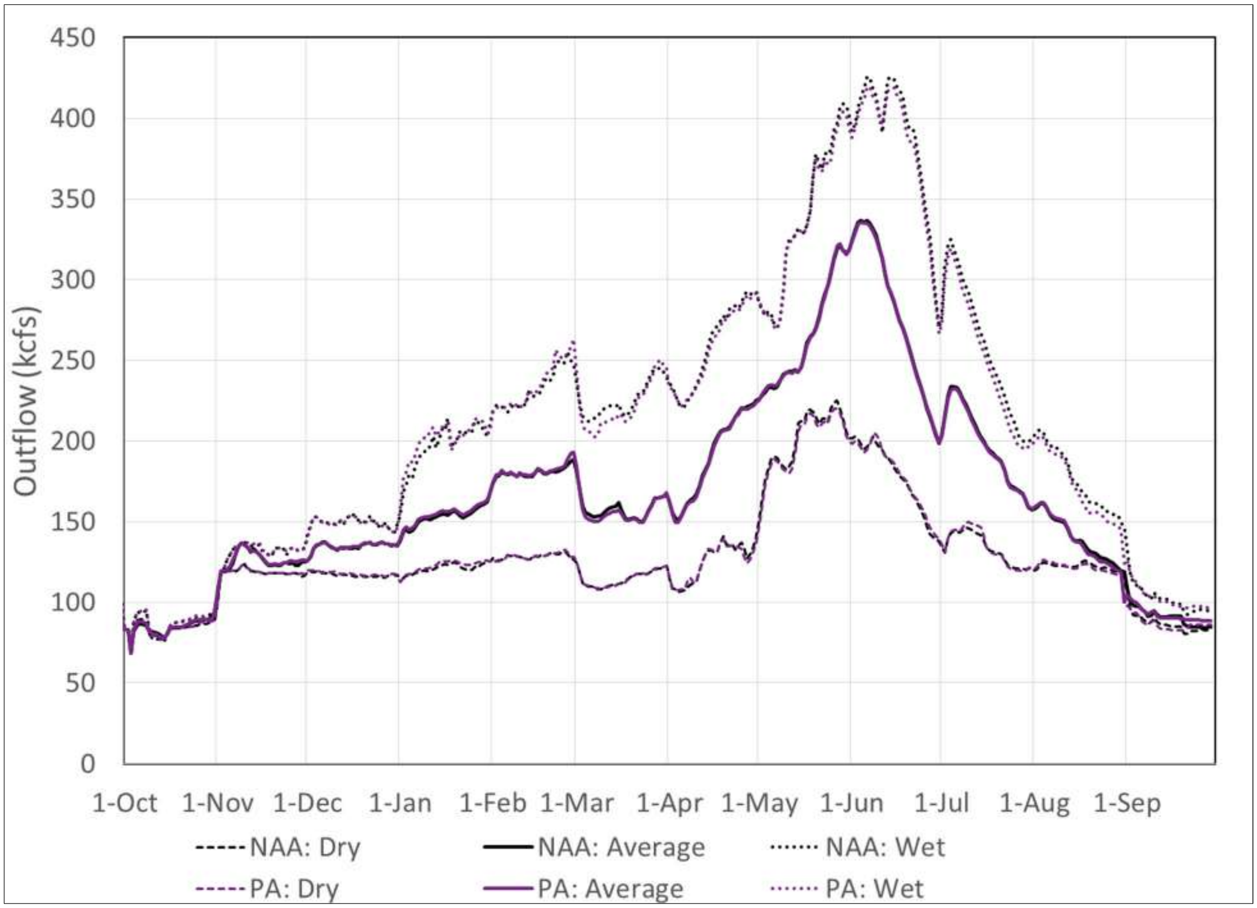

Figure 2.9-4. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[324] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment

[324] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

The Action Agencies propose to continue to maintain Bonneville Dam and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Overall, scheduled maintenance activities are expected to continue to negatively affect very few CR chum salmon that are migrating during scheduled maintenance periods, but migration periods will be continuously monitored and maintenance will be scheduled to avoid impacts. Non-routine and unscheduled maintenance can affect juvenile and adult passage and survival, especially if these events occur during the freshet, but because they are sporadic in nature and coordinated through the inseason adaptive management process, the alternative measures as coordinated in FPOM (e.g., alternative ladder operations, spill, or turbine unit priorities) will likely minimize these impacts.

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (EPA 2018, Perhar and Arhonditsis 2014). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on CR chum salmon are likely to be very small and are not expected to detectably affect reach survival estimates.

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency hypothetically increases the exposure of CR chum salmon juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile CR chum salmon spend less than a few weeks in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

The effects of the proposed hydrosystem operations and the non-operational measures on CR chum salmon and its habitat are described below.

2.9.3.1.1 Hydrosystem Operation

Access to spawning habitat in the Ives/Pierce Islands area below Bonneville Dam, including natural and constructed spawning habitats in Hamilton Creek, is primarily a function of the Bonneville tailwater elevation. Chum redds in this area have the potential to become dewatered by hydrosystem operations during low flow years. Since 2000, the Action Agencies have coordinated with the TMT to provide a tailwater elevation below Bonneville Dam of approximately 11.5 feet beginning the first week of November (or when chum arrive) and ending by December 31, if reservoir elevations and climate forecasts indicate this operation can be maintained through incubation and emergence. In addition to flow regulation, tides, wind, and unregulated inflows to the Columbia River all influence the tailwater elevation below Bonneville Dam. Thus, the range of outflows from Bonneville Dam required to maintain a tailwater elevation of 11.3 feet can vary from 58 kcfs, which is less than the project minimum discharge, up to 135 kcfs when downstream tributary flows are well below average. When rain events increase flows, the chum operations are modified to pass extra flows during nighttime hours as much as possible, which is less harmful to chum spawning success than is increasing the flows during the day (Tiffan et al. 2009). Bonneville Dam typically starts its spring spill around April 10. If the emergence period extends beyond April 10th, and a decision is made to maintain the tailwater, TMT discusses potential further actions to protect fish in the gravel from impacts of TDG associated with spill. These further actions may include delaying the start of spill or releasing additional flows to provide depth compensation for fish in the gravel.

The proposed continuation of operations for chum spawning, incubation, and egress will improve chum productivity; however, maintaining chum flow augmentation throughout the winter and early spring has the potential to jeopardize spring refill objectives at Grand Coulee Dam during low water years. When this scenario arises, the TMT may recommend dewatering chum redds in the mainstem Ives/Pierce Island area. Factors influencing this decision include the number and location/elevation of chum redds, predicted emergence timing based on available temperature data, status of the storage reservoir elevations, water supply forecasts, and status of upriver listed stocks.

The proposed increase in spring spill will result in: 1) higher proportions of juveniles passing downstream via the spillway than via the juvenile bypass or corner collectors, and 2) exposure to increased levels of TDG for any chum salmon fry that are still present in Bonneville Reservoir or downstream of Bonneville Dam in April and May. Chum salmon fry that remain in shallow water in or near the Ives Island spawning area during this period are likely to experience an increase in TDG exposure that could increase the incidence of injury or death (Geist et al. 2013). During years when low flows and tailwater elevations (less than about 12.5 foot) are forecasted for Bonneville Dam in early April, the TMT may recommend providing additional flows during the first 1 to 2 weeks of the spring spill period to provide depth compensation for CR chum eggs and fry that are still present. Assuming typical water temperature conditions, the majority of chum salmon fry (approximately 80 percent) are likely to have emerged and migrated to the ocean by the time spring spill begins on April 10 (Murray et al. 2011, Hillson et al. 2017). Adults, which migrate and spawn in the fall, will be unaffected by the flexible spring spill operation.

The proposed operations at Libby Dam, Hungry Horse Dam, and Grand Coulee Dam will not affect adult or juvenile migration or survival because the operations would only affect summer flow, which is not when juvenile or adult chum migrate. The proposed operation at Dworshak Dam will reduce the spring flow experienced by juvenile chum salmon in the lower Columbia River by a small amount, but only in high flow years. Thus, we do not expect any observable differences in time between emergence from spawning gravels and arrival at the estuary, or exposure to predators, due to the decreased flows during high flow years. Adult migrants will not be affected.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as that produces the most power for a given volume of water. This range, unless there is project-specific information available, generally provides the best passage conditions and survival rates for salmonids passing through the units (Skalski et al. 2002). Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for adult and juvenile salmonids passing through the turbine units, but the number of CR chum salmon affected should be extremely low because of the limited time frame.

Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure and improve ladder attraction conditions for adult CR chum salmon, but would also slightly reduce turbine unit survival for adult and juvenile salmonids passing through the turbine units, and would also increase powerhouse passage rates for juveniles. These flow levels would be expected to occur in up to 5 to 10 percent of the years at Bonneville Dam; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur. Operating turbine units above the 1 percent efficiency range resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is an average of 8 to 30 hours per project, with a maximum of 8 to 80 hours per project, for lower Columbia River dams, from April through June. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. Overall adult survival rates of CR chum salmon originating or migrating above Bonneville Dam should not be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1% peak efficiency range because they do not migrate when this will occur. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of CR chum salmon through Bonneville Dam, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

2.9.3.1.2 Predation Management and Monitoring Actions

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. The current strategy (fishery) removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that numbers of CR chum salmon handled or killed in the Sport Reward Fishery will be no more than 10 adults and 100 juveniles per year. Since the likelihood of the Dam Angling Program being implemented at Bonneville Dam is not reasonably certain to occur, it is unlikely that it will have an effect on the abundance of any CR chum salmon populations.

Adult chum salmon that pass Bonneville Dam in relatively low numbers (an estimated 10 to 500 per year) will be impacted by the proposed action. We expect the Corps' program to haze pinnipeds and install and operate sea-lion excluder gates at Bonneville Dam in the fall, and assistance with removal programs, to continue to reduce the presence of Steller sea lions and predation on adult chum salmon near Bonneville Dam. The Action Agencies will continue to monitor and estimate the impact that pinnipeds are having on chum salmon and adjustments will be made to the hazing, dissuasion, and monitoring program in coordination with NMFS to adaptively manage as information becomes available.

2.9.3.1.3 Habitat Actions

For CR chum salmon populations that have been negatively affected by CRS operations and maintenance, the Action Agencies will provide funding and/or technical assistance for habitat improvement actions in tributaries to the lower Columbia River consistent with recovery plan implementation priorities and other regional efforts, as funding allows. If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could benefit the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for CR chum salmon as part of this proposed action, or proposed such actions in a manner allowing us to meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential actions in our jeopardy analysis.

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). Program goals are to increase the extent and quality of estuarine ecosystems and improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) and their availability to CR chum salmon as they rear in and migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty in predicting the timing and accomplishment of habitat restoration actions and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway. Continued implementation of the monitoring program will either confirm that these floodplain reconnections are enhancing conditions for salmonids such as CR chum salmon as they rear in and migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design can improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during the period covered by this consultation and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during the period of the proposed action, increasing the availability of rearing habitat and the flux of insect and amphipod prey to the mainstem migration corridor for juvenile CR chum salmon. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[325] of all CR chum salmon populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.9.3.1.4 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for the impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail within the site-specific biological opinions referenced therein (see Section 2.9.2.7). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.9.3.1.5 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile chum salmon are likely to be present in shallow shoreline areas, an unknown portion of the ESU will continue to be stunned, harmed or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this ESU that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The present, 5-year average number of observed juvenile salmonids being stunned and harmed annually by the project is 90,000 per year. Some of this take could result in injury or reduced fitness. This average will be used as a benchmark to

[325] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile chum salmon opportunities to move into wetland habitats for food and refuge from predators. Moreover the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the CR chum salmon ESU.

evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[326]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of CR chum salmon will be affected each year:

- Activities associated with the Smolt Monitoring Program and the CSS:
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - Zero hatchery and 500 natural-origin juveniles will be handled.
  - Zero hatchery and 10 natural-origin juveniles will die.
- Activities associated with all other RME programs:
  - 20 hatchery and 400 natural-origin adults will be handled.
  - One hatchery and four natural-origin adults will die.
  - 40,000 hatchery and 1,000,000 natural-origin juveniles will be handled.
  - 400 hatchery and 7,000 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program will, on average, affect 2.2 percent of the natural-origin adult (recent, 5-year average) run (arriving at mouth of the Columbia River) and 14.6 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to less than 1 percent of estimated ESU abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations

[326] Ongoing and future discussions are expected to lead to substantial reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

(including facilities modifications and mitigation actions), the effects of the RME programs on abundance are acceptable and warranted.

2.9.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small reduction in obstructions at lower Columbia River dams for individuals from the Upper Gorge CR chum salmon population. Implementation will also affect the volume and timing of flow in the Columbia River, which alters habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.9-7.

Table 2.9-7. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the CR chum salmon ESU.

PBF	Effect of the Proposed Action
Freshwater spawning sites	Continued inundation of some chum salmon spawning sites in the lower ends of tributaries under Bonneville Reservoir (reduced availability of sites for spawning, incubation, and larval development for the Upper Gorge population. We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is likely to be available for spawning within the 5-foot operating range. Continued implementation of flow measures to provide a minimum tailwater elevation below Bonneville Dam for access to spawning habit in the mainstem and local tributaries (access to substrate supporting spawning, incubation, and larval development). Except in years with low water storage in upper basin reservoirs this will ensure adequate water quantity and space for spawning and incubation.
Freshwater rearing sites	See “estuarine areas.”
Freshwater migration corridors	Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies’ ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. Proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not change the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring when juvenile CR chum salmon are migrating, and warmer temperatures in the fall when adult CR chum salmon enter the lower Columbia River. In general, cooler spring temperatures will not negatively affect the functioning of water quality in the mainstem migration corridor for juveniles. However, this will continue to negatively affect water quality in the adult migration corridor for the

PBF	Effect of the Proposed Action
	earliest individuals. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of proposed operations. Continued reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous fishes in the lower Columbia River and the plume (ongoing reduction in “natural cover”). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of proposed operations. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining). The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use “environmentally acceptable lubricants” where feasible. Increased levels of TDG in the upper gorge and at least 35 miles downstream of Bonneville Dam during spring spill (water quality). The risk of adverse effects (incidence of GBT) is moderate for chum salmon fry that have not migrated to the ocean by the time the flexible spring spill operation begins at Bonneville Dam on April 10. Continued small increases in obstructions for adult chum salmon during routine outages of fishways or turbine units at Bonneville Dam. Small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities. Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Continued deployment of sea-lion exclusion devices and hazing at Bonneville Dam in the fall to maintain the protection of adult chum salmon that reach the fishways at current levels (ongoing reduction in predation). Continued implementation of the NPMP to maintain levels of fish predation (ongoing reduction in predation) at recent levels.
Estuarine areas	Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels and juvenile and adult forage). This will increase opportunities

PBF	Effect of the Proposed Action
	for juvenile chum salmon to access sites used for growth and for the transition to life in the ocean. Continued implementation of the NPMP to control levels of fish predation (reduction in levels of predation).

2.9.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.9.1), Environmental Baseline (Section 2.9.2), and Effects of the Action (Section 2.9.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including CR chum salmon.

NMFS has also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and are included in the environmental baseline. Some of the activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area, including CR chum.

2.9.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.9.5.1 Species

The CR chum salmon ESU includes 17 historical populations in three distinct ecological regions: Coast Range (seven), Cascade Range (eight), and Columbia Gorge (two). Each ecological region is considered to be equivalent to an MPG. CR chum salmon are at very low population levels throughout their range, primarily due to degraded or lost access to spawning and rearing habitat in tributaries. Mainstem habitat in the lower Columbia River and estuary has also been substantially degraded, and access to large amounts of historically available rearing habitat has been blocked.

The Lower Gorge population of CR chum salmon is the population most affected by basinwide (and Bonneville Dam) water management operations, but it has access to both mainstem and tributary habitat spawning areas. This population has generally been stable or increasing in abundance and was rated as viable (i.e., as having a low extinction risk) in the most recent status review, indicating that this, and likely other, populations can persist and increase in abundance under the recent seasonal flow conditions that are expected to continue under the proposed action. The most recent 5-year geometric mean abundance data (2014 to 2018) suggests that the

Upper Gorge Tributaries population has declined slightly, but that most other populations for which estimates are available have increased substantially in abundance compared to the 2009 to 2013 geometric mean estimate. Recent poor ocean conditions associated with a marine heatwave and its lingering effects have likely contributed to lower than average ocean survival rates in recent years. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants. The Upper Gorge population has a rating (very high extinction risk) similar to all but one (Grays/Chinook Rivers population) of the Coastal and Cascade populations of chum salmon.

Only adults and juveniles from the Upper Gorge population must migrate past Bonneville Dam to reach their natal spawning areas or migrate to sea. Both the Upper and Lower Gorge population can be affected by Bonneville Dam operations and maintenance and system-wide water management operations. Structural and operational improvements at Bonneville Dam and protective scheduled maintenance windows should improve passage conditions for juvenile chum salmon from the Upper Gorge population. The proposed 125 TDG spring spill operation should further increase spill levels at Bonneville Dam (limited to 150 kcfs) which will increase juvenile exposure of both populations to TDG beginning April 10. Increased TDG levels would be likely to negatively impact incubating and emerging chum salmon spawning below Bonneville Dam, especially under lower flow conditions when the tailwater elevations are low and do not provide depth compensation for the redds. Other operations (e.g., upper Columbia operations to better protect resident species, Dworshak Dam winter operations to reduce TDG in the lower Clearwater River, operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, etc.) could, collectively, have a small, negative effect, especially on juvenile migrants. However, these effects should not measurably alter juvenile survival rates, and overall juvenile passage survival should be maintained or should increase slightly as a result of this proposed operation.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving CR chum salmon abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this ESU. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Predation on juvenile chum salmon by Caspian terns, Double crested cormorants, and other predatory birds appears to be negligible in the lower Columbia River and estuary. Increased numbers of native and nonnative fishes that likely prey on juvenile CR chum salmon are present in the hydrosystem reach. The NPMP is expected to continue providing similar benefits of predator removal (northern pikeminnow). This program is maintaining current (reduced) levels of predation, which creates conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on CR chum salmon in the lower Columbia River and estuary has likely increased with recent increases in the abundance of sea lions. Sea lions are present in the Bonneville Dam when adult CR chum salmon are present. There are anecdotal observations of sea lions eating CR chum salmon below Bonneville Dam, but no estimates of losses are available. Sea lion predation downstream of Bonneville Dam, including the estuary, is likely to negatively affect the productivity and abundance of CR chum salmon.

The past effects of artificial production programs (e.g., Grays River, Washougal River Hatchery / Duncan Creek programs in Washington) have largely been to increase abundance and help preserve genetic resources—especially true for safety net or conservation hatchery programs during times of low abundance. However, these programs may also pose risks to natural productivity and genetic diversity of the affected populations.

As described in Section 2.9.4, the cumulative effects of state and private actions that are reasonably certain to occur within the portion of the action area are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect CR chum salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of CR chum salmon as moderate. We generally expect that abundance could decrease and extinction risk increase as a result of climate change. However, the severity of those changes would be reduced as a result of the proposed action.

Fall migrating adults could potentially respond temporally to changing environmental conditions by migrating and spawning later in time. Because chum salmon preferentially spawn in areas with groundwater seeps, they may not be affected substantially by warming winter temperatures, but may still be affected by winter flood events. Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in the lower river and estuary, but, because they typically spend little time in freshwater, they would avoid exposure to higher summer temperatures. Though the quality of information is mixed, sensitivity in the marine stage likely exists, and exposure to changing marine conditions, including high levels of ocean acidification, will occur. These climate change consequences are not caused by the proposed action, and elements of the proposed action (estuary habitat restoration and research, monitoring, and evaluation programs) should help to improve the resiliency of CR chum salmon populations to expected climate change effects. In simple terms, even if the adult abundance declines somewhat as a result of climate change, which will make recovery of this ESU somewhat more challenging, it will have declined less as a result of the proposed action because the proposed action is expected to improve the functioning of VSP parameters and thus positively contribute to the survival and recovery of the species.

The proposed action includes conservation measures to mitigate the potential adverse effects of the action, in many cases by addressing baseline limiting factors for survival and recovery. These measures include managing flows for chum spawning below Bonneville Dam and estuary habitat improvement and predator management actions that should benefit VSP parameters, thus reducing the expected abundance declines caused by climate change. Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this ESU (e.g., dam passage survival, population productivity, degraded estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.).

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity, especially for those populations upstream of Bonneville Dam. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., estuary habitat, predation, etc.). For the Columbia Gorge populations, evidence suggests that these actions have contributed to improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The proposed action carries forward structural and operational improvements at Bonneville Dam since 2008 and improves upon them. Additional juvenile survival improvements are expected from the flexible spring spill operation, and ecosystem functions should continue to increase in estuary habitats where improvement actions occur.

Climate change is a substantial threat to CR chum salmon, especially during the marine rearing phase of their life cycle. The proposed action should not exacerbate either the scope and/or the severity of those impacts.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of CR chum salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of CR chum salmon.

2.9.5.2 Critical Habitat

Critical habitat for CR chum salmon encompasses six subbasins in Oregon and Washington containing 18 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2013b) and have some, or high, potential for improvement. The removal of some large tributary dams has improved habitat quality in spawning and rearing areas in the lower reaches of these streams. However, similar to the discussion above regarding effects on the species, the status of critical habitat is likely to be affected by climate change, with predicted rising temperatures and alterations in stream flow patterns.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat in mainstem spawning areas and the juvenile and adult migration corridors for CR chum salmon. Some of these past effects will continue: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), alteration of the seasonal temperature regime, and for the Upper Gorge population with spawning areas above Bonneville Dam, longer travel times and passage delays (obstructions in the migration corridor). These factors have increased the likelihood of excessive predation on juvenile and adult CR chum salmon and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The CRS operations also will continue to inundate some spawning habitat in the lower reaches of the tributaries to Bonneville Reservoir (substrate). However, the Action Agencies will continue to provide a minimum tailwater elevation (water quantity) for access to the mainstem spawning area and several local tributaries below Bonneville Dam (substrate) when the water storage and supply forecasts indicate this is feasible. Based on their past record, we expect that this operation will fully support chum spawning, incubation, and migration in most water years. Increased levels of TDG during the flexible spring spill operation will increase the risk of GBT within Bonneville Reservoir and for at least 35 miles downstream. This will constitute a moderate negative effect on water quality in rearing areas and the juvenile migration corridor for chum salmon fry that have not migrated from the upper and lower gorge areas before April 10, and a smaller effect on water quality in the juvenile migration corridor overall. The spring spill operation will not affect water quality in the migration corridor or in spawning areas for adult chum salmon, which enter the Columbia River during late fall and complete spawning during December and January.

The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors for this species. The thermal inertia created by the CRS reservoirs will continue to negatively affect temperatures (water quality) in the adult migration corridor. Operating the turbine units at Bonneville and The Dalles Dams above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improved water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction for adults from the Lower Gorge and Upper Gorge Tributaries populations. However, by increasing powerhouse flows, it will increase obstructions by a small amount because some adults will fall back or juveniles will move downstream through turbines. In summary, the proposed action is not likely to further limit water quantity or water quality or to increase obstructions in the juvenile or adult migration corridors by a meaningful amount.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors.

In the Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the lower Columbia River estuary, many of these funded through the CRS program. The Action Agencies' proposed estuary habitat program will continue to reconnect an average of 300 acres of the historical floodplain per year, increasing access to rearing areas used extensively by juvenile chum salmon (improved water quantity, natural cover, and forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Reducing numbers of northern pikeminnows will continue to control predation in the migration corridor for juveniles, as will the hazing of pinnipeds and deployment of sea lion excluder devices for adults.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of CR chum salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of CR chum salmon designated critical habitat.

2.9.6 Conclusion

After reviewing and analyzing the current status of CR chum salmon and critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CR chum salmon or destroy or adversely modify its designated critical habitat.

2.10 Lower Columbia River (LCR) Chinook Salmon

This section applies the analytical framework described in Section 2.1 to the LCR Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the LCR Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.10.1 Rangewide Status of the Species and Critical Habitat

The status of the LCR Chinook salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.10.1.1 Status of the Species

2.10.1.1.1 Background

On March 24, 1999, NMFS listed the LCR Chinook salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160). The most recent status review, in 2016, concluded that this ESU should retain its threatened status (81 FR 33468). Critical habitat was designated on September 2, 2005 (70 FR 52630). The summary that follows describes the status of LCR Chinook salmon. More information can be found in the recovery plan (NMFS 2013b) and the most recent status review (NMFS 2016i).[327]

The LCR Chinook salmon ESU includes all naturally spawned populations from the mouth of the Columbia River upstream to and including the White Salmon River in Washington and the Hood River in Oregon. It also includes the Willamette River upstream to Willamette Falls (exclusive of spring-run Chinook salmon in the Clackamas River), and 15 artificial propagation

[327] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

programs (70 FR 37160).[328] This ESU comprises 32 independent populations, which are grouped into the following six MPGs based on combinations of ecoregions (Coast, Cascade, Gorge) and life-history type (spring, fall, late fall): Coast fall, Cascade spring, Cascade fall, Cascade late-fall, Gorge fall, and Gorge spring.[329]According to the most recent status review, twenty-seven populations are at very high risk of extinction, two populations are at high risk of extinction, one population is at moderate risk of extinction, and two populations are at very low risk of extinction (NMFS 2016i).

2.10.1.1.2 Life-History and Factors for Decline

LCR spring Chinook salmon populations are stream-type, while LCR early-fall and late-fall Chinook salmon populations are ocean-type. Stream-type populations have a longer freshwater residency, perform extensive offshore migrations, and are most commonly found in headwater streams of large river systems. Ocean-type populations are more commonly found in coastal streams and typically migrate to sea within the first 3 months of life. Other life-history differences among run types include the timing of spawning, incubation, emergence in freshwater, migration to the ocean, maturation, and return to freshwater. This life-history diversity allows different runs of Chinook salmon to use streams as small as 10 feet wide and rivers as large as the mainstem Columbia (NMFS 2013b). Stream characteristics determine the distribution of run types among LCR streams. Depending on run type, juvenile LCR Chinook salmon may rear for a few months to a year or more in freshwater streams, rivers, or the estuary before migrating to the ocean in spring, summer, or fall. This diversity is an important characteristic of the ESU.

LCR spring Chinook salmon spawn primarily in upstream, higher elevation portions of large subbasins. Adults enter the lower Columbia River from March through June, well in advance of spawning in August and September. Fall Chinook salmon, commonly referred to as "tules," spawn in moderate-sized streams and large river mainstems, including most tributaries of the lower Columbia River. Most LCR fall Chinook salmon enter freshwater from August to September and spawn from late September to November, with peak spawning activity in mid-October. Late-fall Chinook salmon, commonly referred to as "brights," generally return later

[328] Big Creek Tule Fall Chinook, Astoria High School (Salmon and Trout Enhancement Program also known as STEP) Tule Fall Chinook, Warrenton High School (STEP) Tule Fall Chinook, Cowlitz Tule Fall Chinook Salmon Program, North Fork Toutle Tule Fall Chinook, Kalama Tule Fall Chinook, Washougal River Tule Fall Chinook, Spring Creek National Fish Hatchery (NFH) Tule Chinook, Cowlitz spring Chinook salmon (two programs), Friends of Cowlitz spring Chinook, Kalama River Spring Chinook, Lewis River Spring Chinook, Fish First Spring Chinook, and Sandy River Hatchery Spring Chinook salmon (ODFW stock #11). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including LCR Chinook salmon (81 FR 72759). The proposed changes for hatchery program inclusion in this ESU were to add the Klaskanine Hatchery Program Fall, Deep River Net Pens-Washougal Program Fall, Bonneville Hatchery Program Fall, and Cathlamet Channel Net Pens Program Spring. We expect to publish the final revisions in 2020. For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c).

[329] The W/LC TRT used the term "strata" to refer to these population groupings, which are significant in identifying delisting criteria. The strata are analogous to the "major population groups" defined by the ICTRT. For consistency, we use the term "major population group" throughout this opinion.

than tule fall Chinook salmon, are less mature when they enter the Columbia River, and spawn later in the year. Late-fall Chinook salmon enter the Columbia River from August to October and spawn from November to January, with peak spawning in mid-November (NMFS 2013b).

By the time of listing, populations of LCR Chinook salmon had declined substantially from historical levels. Of the 32 populations in the ESU, only the two late-fall runs—the North Fork Lewis and Sandy—were considered viable. Most (26 out of 32) had a very high extinction risk (and some were extirpated or nearly so) (NMFS 2013b). Low abundance, poor productivity, losses of spatial structure, and reduced diversity all contributed to the very high extinction risk for most LCR Chinook salmon populations. Many of the populations were believed to have very low abundance of natural-origin spawners (100 fish or fewer), which subjected them to genetic and demographic risks. Other populations had higher total abundance, but several of these also had high proportions of hatchery-origin spawners. Spatial structure had been substantially reduced in several populations. Low abundance, past broodstock transfers, and other legacy hatchery effects, and ongoing hatchery straying, may have reduced genetic diversity within and among LCR Chinook salmon populations. Hatchery-origin fish spawning naturally may also have reduced population productivity (LCFRB 2010, ODFW 2010).

2.10.1.1.3 Recovery Plan

The ESA recovery plan for LCR Chinook salmon (NMFS 2013b) includes delisting criteria for the ESU, along with identification of factors currently limiting its recovery, and management actions necessary for recovery. The biological delisting criteria are based on recommendations by the W/LC TRT.[330] They are hierarchical in nature, with ESU-level criteria based on the status of natural-origin LCR Chinook salmon assessed at the population level. The plan identifies ESU- and MPG-level biological criteria, and within each MPG, it identifies a target risk status for each population, consistent with the MPG-level criteria. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the ESU will require sufficient improvement in its abundance, productivity, spatial structure, and diversity.

2.10.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within an ESU based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the W/LC TRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low extinction risk. For LCR Chinook salmon,

[330] The recovery plan also includes “threats criteria” for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

recovery requires improving all six MPGs to a high probability of persistence or a probability of persistence consistent with their historical condition.

NMFS' most recent status review (NMFS 2016i) found that overall, there had been little change in status from the previous review. Table 2.10-1 lists the MPGs and populations in this ESU and summarizes their abundance/productivity, spatial structure, diversity, and overall population risk status at the time of the most recent status review; it also summarizes their target risk status for delisting (NMFS 2013b, 2016i; NWFSC 2015). Abundance and productivity risk ratings for LCR Chinook salmon populations were high to very high for most populations, except for spring Chinook salmon in the Sandy River (moderate) and late-fall Chinook salmon in the North Fork Lewis and Sandy Rivers (very low for both).

Table 2.10-1. LCR Chinook salmon population-level risk for abundance/productivity (A/P), spatial structure, diversity, overall extinction risk as of the most recent status review (NWFSC 2015, NMFS 2016i), and recovery plan target status (NMFS 2013b). Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH). The populations that spawn upstream of Bonneville Dam are highlighted in gray.

MPG		Population	A/P Risk Rating	Diversity Risk Rating	Spatial Structure Risk Rating	Overall Extinction Risk Rating	Recovery Plan Target Extinction Risk Rating
Ecological Subregion	**Run Timing**						
Cascade	**Spring**	Cowlitz (WA)	VH	M	H	VH	VL
		Cispus (WA)	VH	M	H	VH	VL
		Tilton (WA)	VH	VH	VH	VH	VH
		Toutle (WA)	VH	H	L	VH	M
		Kalama (WA)	VH	H	L	VH	H
		Lewis (WA)	VH	M	H	VH	L
		Sandy (OR)	M	M	M	M	L
	Fall	Lower Cowlitz (WA)	VH	M	L	VH	L
		Upper Cowlitz (WA)	VH	M	VH	VH	H
		Toutle	VH	M	L	VH	VL
		Coweeman (WA)	H	L	L	H	VL
		Kalama (WA)	VH	M	L	VH	M
		Lewis (WA)	VH	L	L	VH	VL

MPG		Population	A/P Risk Rating	Diversity Risk Rating	Spatial Structure Risk Rating	Overall Extinction Risk Rating	Recovery Plan Target Extinction Risk Rating
Ecological Subregion	**Run Timing**						
		Salmon Creek (WA)	VH	M	L	VH	H
		Clackamas (OR)	VH	H	VL	VH	M
		Sandy (OR)	VH	H	M	VH	M
		Washougal (WA)	VH	M	L	VH	VL
	Late-fall	NF Lewis (WA)	VL	L	L	VL	VL
		Sandy (OR)	VL	M	M	L	VL
Columbia Gorge	**Spring**	White Salmon (WA)	VH	VH	VH	VH	M
		Hood (OR)	VH	VH	VL	VH	VL
	Fall	Lower Gorge (WA & OR)	VH	H	M	VH	M
		Upper Gorge (WA & OR)	VH	H	M	VH	M
		White Salmon (WA)	VH	H	H	VH	M
		Hood (OR)	VH	H	VL	VH	L
Coast Range	**Fall**	Youngs Bay (OR)	H	H	VL	H	H
		Grays/Chinook (WA)	VH	VH	L	VH	L
		Big Creek (OR)	VH	H	L	VH	H
		Elochoman/ Skamokawa (WA)	VH	H	L	VH	L
		Clatskanie OR)	VH	H	VL	VH	L
		Mill/Abernathy /Germany (WA)	VH	H	L	VH	L

MPG		Population	A/P Risk Rating	Diversity Risk Rating	Spatial Structure Risk Rating	Overall Extinction Risk Rating	Recovery Plan Target Extinction Risk Rating
Ecological Subregion	Run Timing						
		Scappoose (OR)	H	H	L	H	L

The most recent status review did note some positive trends. It noted increases in abundance in about 70 percent of the fall-run populations and decreases in hatchery contributions for several populations. Overall, there had been some improvement in the status of a number of fall-run populations, although most were still far from recovery goals (Table 2.10-1, Figure 2.10-1) (NWFSC 2015, NMFS 2016i).

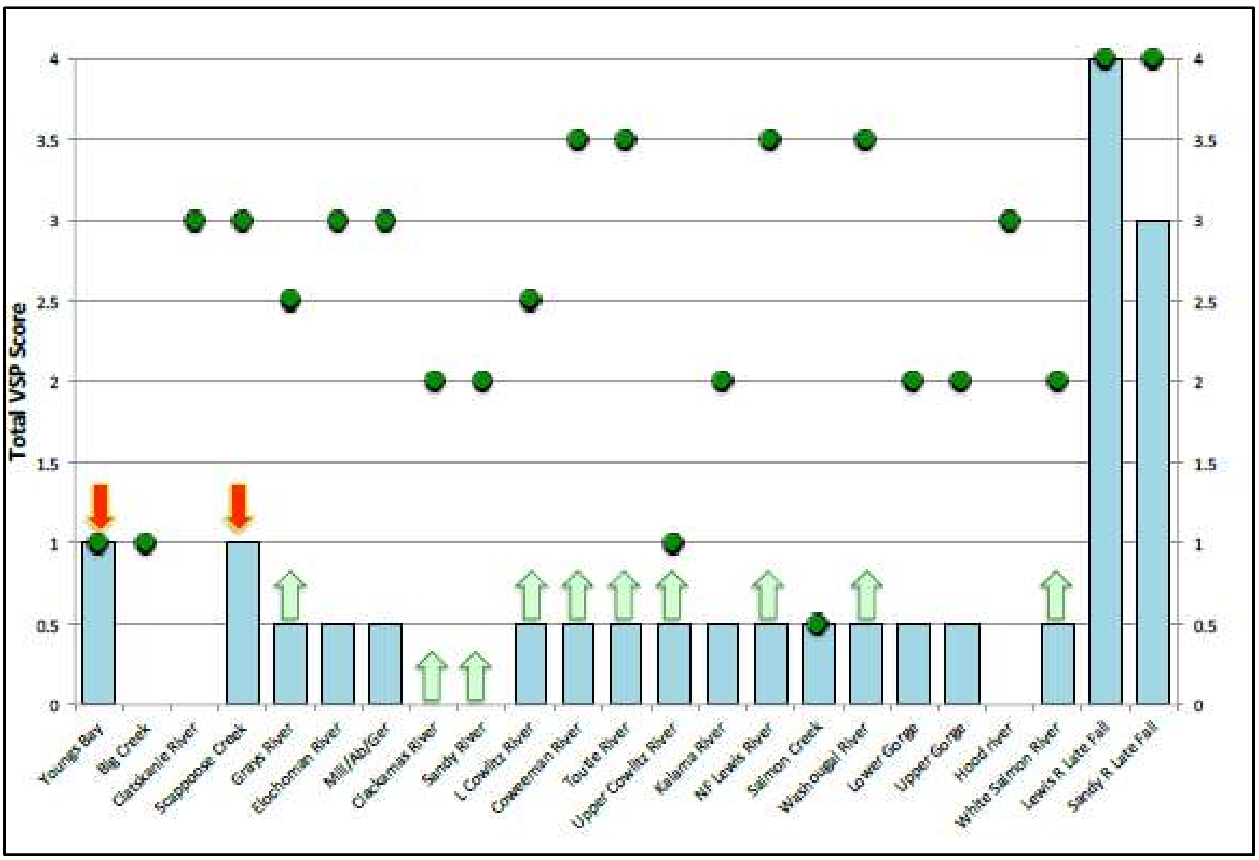

Figure 2.10-1. VSP status of fall-run and late-fall-run, demographically independent populations in the LCR Chinook salmon ESU. Bars indicate the initial viable salmonid population (VSP) status (as identified in the recovery plan; NMFS 2013b); green circles indicate the recovery goals. Arrows indicate the general direction, but not the magnitude, of any VSP score based on new data reviewed in NWFSC (2015). VSP scores represent a combined assessment of population abundance and productivity, spatial structure, and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5 percent risk of extinction within a 100-year period.

Spring-run populations in the ESU were generally unchanged, with most of the populations remaining at a high or very high risk of extinction due to low abundances and high proportion of hatchery origin fish spawning naturally. In contrast, the Sandy River spring-run Chinook salmon population was considered at moderate risk of extinction. Many of the spring-run populations rely on passage programs at tributary dams, and insufficient juvenile passage systems at these dams remain an impediment to establishing and maintaining self-sustaining natural populations. The removal of Condit Dam on the White Salmon River provided an opportunity for the reestablishment of a spring-run population with volitional access to historical spawning grounds. Overall, there had been some improvement in the status of a number of spring-run populations, although most were still far from recovery goals (Figure 2.10-2) (NWFSC 2015, NMFS 2016i).

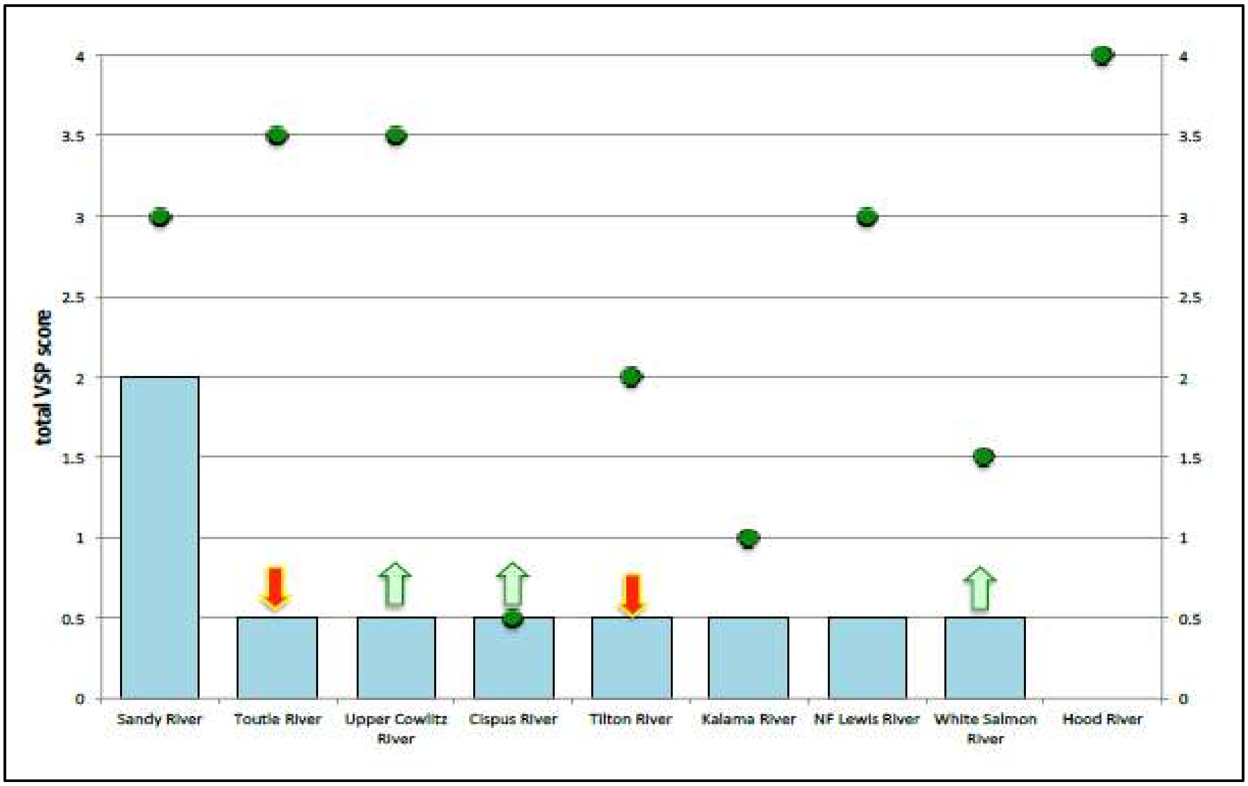

Figure 2.10-2. VSP status of spring-run, demographically independent populations in the LCR Chinook salmon ESU. Bars indicate the initial viable salmonid population (VSP) status (as identified in the recovery plan; NMFS 2013b); green circles indicate the recovery goals. Arrows indicate the direction, but not the magnitude, of the VSP score change based on new data reviewed in NWFSC (2015). VSP scores represent a combined assessment of population abundance and productivity, spatial structure, and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5 percent risk of extinction within a 100-year period.

2.10.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the LCR Chinook salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed.

LCR Chinook salmon have been—and continue to be—affected by a legacy of widespread habitat degradation in both tributaries and the estuary; the effects of both tributary and mainstem dams; a history of high harvest rates; large-scale hatchery production with associated reductions in productivity and loss of genetic diversity; and predation by native fish, birds, and marine mammals (NMFS 2013b).

Degraded habitat conditions are a primary limiting factor for most LCR Chinook salmon populations. Tributary channel complexity, side channel and floodplain connectivity, water quality, and hydrologic patterns have been degraded by urbanization, agriculture, timber practices, and other land uses. Estuary habitat conditions are important for LCR fall Chinook salmon, and altered hydrology and flow timing in the estuary, as well as loss of side channel and wetland habitat are considered a primary limiting factor for this life-history component of the ESU. Exposure to toxic contaminants in the estuary is also identified as a concern for the entire ESU (NMFS 2013b).

One of the largest factors limiting the spring component of the LCR Chinook salmon ESU has been the existence of tributary dams that block access to core headwater spawning areas in upper subbasins (NMFS 2013b). There have also been a number of notable efforts to restore access to areas upstream of tributary dams. The removal of Condit Dam, Marmot Dam, and Powerdale Dam have not only improved/provided access but also allowed for the restoration of hydrological processes that may improve downstream habitat conditions. Efforts to improve juvenile passage in the Cowlitz and Lewis River subbasins are underway, and it is unlikely that there will be significant improvements in the status of LCR spring-run Chinook salmon populations until these efforts are successful (NMFS 2016i).

Five LCR Chinook salmon populations (Upper Gorge, Hood, and White Salmon fall Chinook and Hood and White Salmon spring Chinook) spawn above Bonneville Dam and are negatively affected to varying degrees by passage issues at Bonneville Dam and inundation of historical spawning habitat by Bonneville Reservoir (NMFS 2013b).

The effects of harvest as a limiting factor began to decline even before LCR Chinook salmon were listed in 1999. The exploitation rate[331] for LCR spring Chinook salmon averaged 51 percent from 1980 to 1991. Since then, harvest rates have been reduced in both ocean and inriver fisheries. Since 2012, LCR fall Chinook salmon (the most heavily harvested component of the ESU) have been managed to an exploitation rate limit that varies from 30 to 41 percent depending on abundance, in line with the recovery plan (NMFS 2018a).

Limiting factors for LCR Chinook salmon include concerns about adverse effects to diversity and productivity as a result of high proportions of hatchery-origin spawners in select basins, with many populations containing over 50 percent hatchery fish spawning naturally. In addition, the release of out-of-ESU stocks remains a concern for this ESU (NWFSC 2015, NMFS 2016i).

Pinniped numbers have increased in the Columbia River basin (Wright 2018), which has led to an increase in predation on LCR Chinook salmon. More than 70,000 fish from listed and unlisted

[331] Exploitation rate is the proportion of the total number of fish from a given natural-origin population(s) or hatchery stock(s) that die from the result of fishing activity in a given year.

salmon and steelhead stocks were consumed by sea lions in the vicinity of Bonneville Dam from 2002 through 2019 (Tidwell et al. 2020). California sea lions have historically accounted for the highest pinniped abundance and consequently the most predation on adult salmonids, but Steller sea lion numbers have increased substantially since the early 2000s and are also a source of mortality for LCR Chinook salmon. Most California sea lions arrive at Bonneville Dam in early April and leave by the end of May. Steller sea lions are not as abundant as California sea lions in the Columbia River; however, in the last 5 years more Steller sea lions were observed consuming both spring and fall Chinook salmon at Bonneville Dam.

The risk posed to LCR Chinook salmon by pinniped predation has not been quantified, but we can make inferences based on studies looking at predation rates for all ESUs and run timing of the LCR Chinook salmon populations. The spring-run stocks are at greatest risk, because their run timing coincides with the period of greatest density of pinnipeds in the Columbia River and below Bonneville Dam (discussed further in the Environmental Baseline section, below). The precise number of animals preying on salmon and steelhead throughout the lower Columbia River and Willamette River is not known.

A variety of nonindigenous fishes in the Lower Columbia River Recovery Domain affect salmon and their ecosystems. A number of studies have concluded that many established nonindigenous species (e.g., smallmouth bass, channel catfish, and American shad) pose a threat to the recovery of ESA-listed Pacific salmon, including LCR Chinook salmon. Threats are not restricted to direct predation; nonindigenous species compete directly and indirectly for resources, significantly altering food webs and trophic structure and potentially altering evolutionary trajectories (Sanderson et al. 2009, NMFS 2010).

2.10.1.1.6 Information on Status of the Species since the 2016 Status Review

We do not have updated dam counts for this species comparable to those discussed in prior sections for interior basin salmon and steelhead, because most LCR Chinook salmon spawning takes place below Bonneville Dam. The best scientific and commercial data available are at the population level (Table 2.10-2) and indicate a mix of recent increases, decreases, and relatively static numbers of natural-origin and total spawners in 2014 to 2018 compared to the 2009 to 2013 period.[332] The direction of "% Change" between recent 5-year geometric means is even mixed within run types: for fall-run Chinook salmon populations, the percent change increased for the Kalama River; Lower Cowlitz River; Washougal River; Grays and Chinook Rivers; and Lower Gorge Tributaries populations and decreased for the Coweeman River; Upper Cowlitz River; White Salmon River; Clatskanie River; and Mill, Abernathy, and Germany Creek populations. Therefore the degree to which abundance has been driven by below-average ocean survival, as described for the interior Chinook salmon ESUs, or by a variety of environmental

[332] The upcoming 2021 status review is expected to include population-level adult returns through 2019, and the 5-year periods used for calculating geomeans will shift forward (i.e., the last period will include 2015 to 2019). Because 2014 adult returns represented a peak at the ESU level for some populations, shifting 2014 to the preceding 5-year grouping is likely to increase the negative percent change.

conditions and management actions in freshwater spawning and rearing habitat, appears to vary between populations.

Table 2.10-2. 5-year geometric mean of natural-origin spawner counts for LCR Chinook salmon, excluding jacks. Number in parenthesis is the 5-year geometric mean of total spawner counts. If there is only a value in parentheses, the total spawner count was the only available data for a population (i.e., there was no or only one estimate of natural spawners for the 5-year period). “% change” is a comparison between the two most recent 5-year periods (2014-2018 compared to 2009-2013). "NA" means not available. An “*” indicates that a data set begins in 2010 so the geometric mean is for 4 years (2010-2013), rather than 5 (2009-2009). Sources: Williams (2020c, e).

MPG	Population	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
Cascade	Kalama River - spring	NA	(544)	89 (89)	44 (44)	-51 (-51)	52 (52)
	North Fork Lewis River - spring	(481)	(200)	(99)	(145)	(46)	NA
	Sandy River - spring	NA	NA	1559 (3261)	2837 (3129)	82 (-4)	NA
	Clackamas River - fall	NA	NA	NA	209 (318)	NA	NA
	Coweeman River - fall	NA	(599)	657* (830)	586 (636)	-11 (-23)	NA
	Kalama River - fall	(5742)	(5996)	494* (7198)	1740 (4567)	252 (-37)	NA
	Lewis River - late fall	(8362)	(6652)	10140* (9214)	11096 (11096)	9 (20)	NA
	Lower Cowlitz River - fall	(4311)	(2637)	2480* (3349)	3148 (4197)	27 (25)	NA
	Toutle River - fall	(3220)	(2817)	313* (1197)	299 (559)	-4 (-53)	NA
	Upper Cowlitz River - fall	(156)	(1935)	2750* (8071)	1851 (2697)	-33 (-67)	NA
	Washougal River - fall	(3448)	(3075)	541* (2794)	929 (1619)	72 (-42)	NA
Columbia Gorge	White Salmon River - spring	NA	NA	NA	10 (67)	NA	NA
	Lower Gorge Tributaries - fall	(1036)	(1159)	872* (881)	3467 (3721)	298 (322)	NA
	Upper Gorge Tributaries - fall	(551)	(846)	573* (1230)	539 (1169)	-6 (-5)	NA

MPG	Population	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
	White Salmon River - fall	(1151)	(1457)	749* (948)	348 (580)	-54 (-39)	NA
Coast Range	Big Creek - fall	NA	NA	NA	11 (2277)	NA	NA
	Clatskanie River - fall	26 (265)	8 (84)	13 (96)	2 (32)	-85 (-67)	NA
	Elochoman River - fall	(1868)	(1059)	81* (713)	91 (293)	12 (-59)	NA
	Grays and Chinook Rivers - fall	(180)	(199)	81 (401)	218 (642)	169 (60)	NA
	Mill, Abernathy, and Germany Creeks - fall	(1593)	(1091)	79* (700)	30 (196)	-62 (-72)	NA
	Youngs Bay - fall	NA	NA	NA	140 (1757)	NA	NA

NMFS will evaluate the implications for extinction risk of these more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.10-2.

2.10.1.2 Status of Critical Habitat

NMFS (2005a) designated critical habitat for LCR Chinook salmon to include all Columbia River estuarine areas and river reaches from the mouth upstream to the confluence with the Hood River (50 CFR, 226.212(h)). Critical habitat for LCR Chinook salmon encompasses nine subbasins in Oregon and Washington containing 39 occupied HUC5[333] watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2013b) and have some, or high, potential for improvement. Similar to the discussion above regarding effects on the species, the status of critical habitat is likely to be affected by climate change, with predicted rising temperatures and alterations in stream flow patterns. Improved access to spawning and rearing habitat, and habitat restoration efforts, will help reduce those effects on critical habitat.

[333] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country. A HUC5 is a five-unit (5 two-digit numbers) code. Examples are “Salmon River-Redfish Lake Creek” (1706020102) in the upper Salmon River basin, Idaho; “Wenatchee River—Icicle Creek” (1709000501) in the Wenatchee Basin, Washington.

Of 39 designated HUC5 watersheds within the range of this ESU, NMFS (2005b) gave 31 a high rating and eight a medium rating for their value to the conservation (i.e., recovery) of the species. The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features, NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b), as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.
- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the

ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.

- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case of freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Critical habitat also has been designated for LCR Chinook salmon in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. NMFS considers the estuary to have a high conservation value because it connects every population with the ocean and is used by rearing and migrating juveniles and by migrating adults.

Human activities since the late 1800s have altered the form and function of the Columbia River estuary, reducing the quantity and quality of its PBFs. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained this environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in the mainstem navigation channel; and causeways have been constructed that restrict the position of tributary confluences.

In addition, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban use. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from upstream reservoirs have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that reduced river flows caused by hydrosystem operations and climate change together have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of established flow variations in the Columbia River estuary through flow regulation may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has eliminated shallow-water habitats, which were seasonally important rearing areas and refugia for juvenile salmonids, particularly for small subyearling migrants such as some LCR Chinook salmon. Disconnecting the tidal river from its floodplain also prevented delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The remainder of the area designated as critical habitat is in the reservoir reach between Bonneville Dam and the Hood River confluence. NMFS (2005b) designated critical habitat in seven occupied HUC5 watersheds in the Middle Columbia/Hood subbasin and rated six as having high and one as having medium conservation value. The reservoir itself is part of the high value rearing and migration corridor connecting important upstream watersheds with downstream reaches and the ocean. Its conservation value has been affected by upstream and downstream passage at Bonneville Dam, and any historical spawning habitat in the lower reaches of the tributaries that had been used by fall-run LCR Chinook salmon populations are now under the reservoir. In most designated tributary watersheds, stream habitat, water quality, and watershed processes have been degraded by development and other land use activities, particularly in low to moderate elevation habitats where fall Chinook salmon spawn and rear.

The effect of these changes as a whole is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs and thus the conservation value of critical habitat for LCR Chinook salmon within the action area are discussed in more detail in the Environmental Baseline section, below.

2.10.1.3 Climate Change Implications for LCR Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of LCR Chinook and aquatic habitat is climate change. The USGCRP[334] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific

[334] http://www.globalchange.gov

Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[335] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

Likely changes in temperature, precipitation, and wind patterns (as well as sea-level rise in the lower estuary) have implications for survival and recovery of LCR Chinook salmon in both their freshwater, estuarine, and marine habitats and the PBFs of their critical habitat. While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (ISAB 2007). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1 to 4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure, and coastal wetlands and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, certain management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations). Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends on both the characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable, so maintaining or promoting the diversity currently found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR Chinook salmon ESU.

[335] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

Climate change would affect LCR Chinook salmon and critical habitat through physical and chemical changes to their habitats (e.g., increased water temperature, decreased ocean pH, changes in the timing and volume of stream flow). The physical and chemical changes may result in biological impacts such as, but not limited to, reduced ocean survival, changes in growth and development, and changes in run timing and spawning timing (Link et al. 2015). These biological changes can lead to changes in species productivity and abundance, distribution, food web structure, community structure, invasive species impacts, and biodiversity and resilience (Link et al. 2015). Crozier et al. (2019) assessed LCR Chinook salmon as having a moderate vulnerability to the effects of climate change based on an analysis of the ESU's sensitivity (moderate) and exposure (high). Further, the species was determined to have a high adaptive capacity because of the high degree of life-history diversity expressed by the different populations (Crozier et al. 2019).[336]

LCR Chinook salmon have a high exposure score for summer stream temperature. If spring-run adults or yearling juveniles are restricted to lower river reaches due to lower flows, summer temperatures might become limiting. This ESU scored moderate for hydrologic regime shift, indicating that reduced snowmelt and higher winter flows may affect these fish in some areas. To access headwater areas, spring-run LCR Chinook salmon rely on high flows from snowmelt during April to June; thus, a reduced spring freshet might require earlier migration. Timing of river entry for the spring run (of LCR Chinook salmon) is triggered by a rising thermograph (Keefer et al. 2008). If spring temperatures are higher and spring flows lower, adults may move into headwater reaches sooner than normal. It is conceivable that their energy stores might be insufficient to over summer through to the early fall spawning period, when temperatures decline. Higher resolution study of specific habitats is needed to clarify the extent of this risk.

Fall-run adults from the LCR Chinook ESU return to fresh water at an advanced state of maturation during September to October. For these fish, river entry is triggered by a falling thermograph, so warmer temperatures may delay arrival at spawning grounds or require fish to hold and spawn in waters at lethal or sublethal temperatures, resulting in direct or indirect mortality (Schreck et al. 2013, Keefer et al. 2018). There is some indication that holding in sublethal temperatures can degrade the quality of both male and female gametes (McCullough et al. 2001, Lahnsteiner and Kletzl 2012). Late-fall adults from this ESU may be less subject to deleterious temperatures given the November timing of their freshwater entry. Timing of maturation and spawning strongly influences the susceptibility of different run types to climate change.

As for all ESUs, warmer winter temperatures will likely accelerate embryonic development and emergence timing. Delayed spawning might reduce temperature effects on emergence timing. However, warmer developmental temperatures can still lead to lowered condition in alevins (Fuhrman et al. 2018), which may have less yolk to tide them over until external food sources are

[336] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results

available. At present, we lack sufficient information on how stream productivity changes with warming temperature to determine whether bioenergetic constraints will be detrimental to salmon. Nevertheless, downstream migration is triggered by flow and facilitated by snowmelt in spring. Whether directly or indirectly, LCR Chinook salmon juveniles will be affected by warmer stream temperatures, as well as by changing estuary and coastal ocean conditions (Daly and Brodeur 2015).

Climate change could affect productivity in tributary habitat through changes in flow and increasing temperatures, which could affect the spawn timing, incubation timing, and rearing and migration timing of LCR Chinook salmon populations. However, it is somewhat unclear how changes in the timing of specific life-history stages would affect survival, if at all, especially during the duration of the effects of the proposed action. Recent analyses by Crozier et al. (2019) rated the vulnerability of LCR Chinook salmon as moderate. NMFS' life-cycle modeling (for SR spring/summer Chinook salmon), which considered three potential levels of changing climate severity over the next 24 years, clearly indicates that climate change effects, especially those that may manifest in the ocean, pose a substantial threat as they can have severe, negative consequences to the overall productivity (and abundance) of all SR spring/summer Chinook salmon populations (see Section 2.2.3.1.12 Life-Cycle Modeling), and likely to other "stream type" Chinook salmon populations as well. Based on the modeling, we expect abundances over the next 24 years to decrease and extinction risk to increase and that LCR Chinook salmon may become more sensitive to smaller perturbations.

2.10.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For LCR Chinook salmon, we focus our description of the environmental baseline on the area where LCR Chinook salmon juveniles and adults are most exposed to the effects of the proposed action. We also consider the broader action area, including tributary habitat, because these areas are important context for understanding the effects of the proposed action.

To determine the upstream extent of LCR Chinook salmon distribution and thus exposure to effects of the proposed action, we reviewed LCR Chinook salmon PIT-tag detections at Bonneville, The Dalles, and McNary Dams from 2013 through 2019. PIT-tag detections are an indication of presence/absence and not absolute abundance because the proportion of the population that is tagged varies from year to year and is not known. The 7-year average of LCR

Chinook salmon detections is six adults at Bonneville Dam, one adult at The Dalles Dam, and close to zero (a single detection in 2018) at McNary Dam (DART 2020b). It is likely that most adults that ascend The Dalles Dam or other upstream dams fall back, through either the turbines or the spillbays or sluiceway (safer routes), to find their natal tributaries. For the purpose of this analysis, we make the conservative assumption that at least some of the LCR Chinook salmon that have ascended these dams have not returned to their respective spawning tributaries. Therefore, the area where LCR Chinook salmon experience the effects of the proposed action is the Columbia River from the tailrace of John Day Dam to the plume,[337] including tributary confluences in this reach to the extent that they are affected by flow management and estuary habitat mitigation actions.

2.10.2.1 Mainstem Habitat

On the mainstem of the Columbia River, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.10-3). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

[337] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

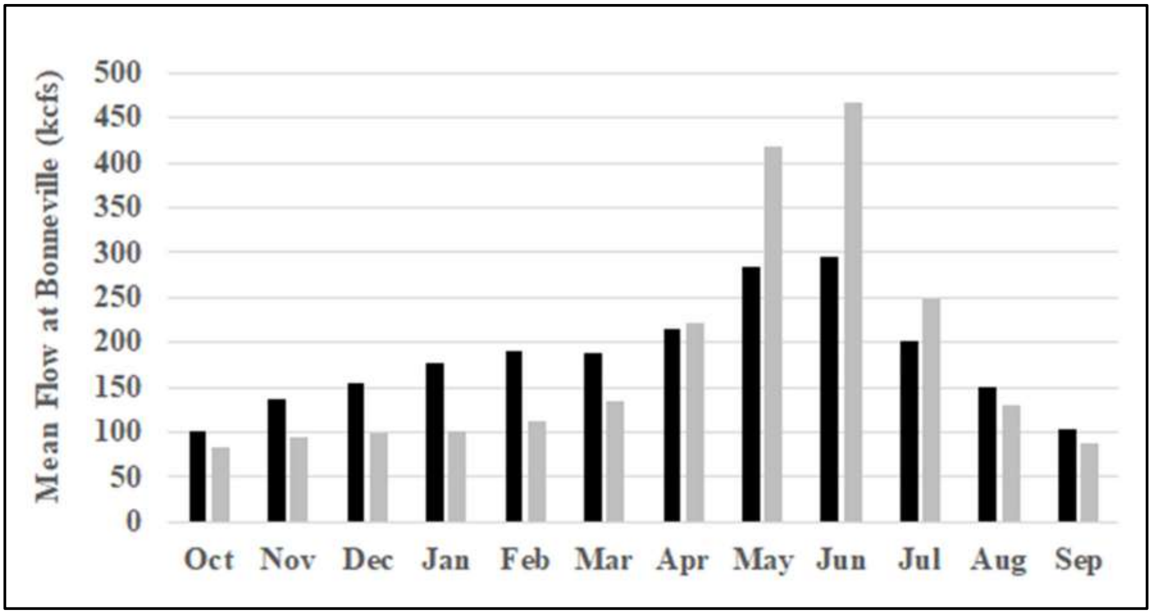

Figure 2.10-3. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[338] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et

[338] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile salmonids and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.10.2.2 Passage Survival

Only five of 32 populations in the LCR Chinook ESU are affected by passage conditions at Bonneville Dam and, to a much lesser extent, The Dalles Dam: the Upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run Chinook salmon populations. The survival of downstream migrants has improved in recent years due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2, and increases in the percentage of flow approaching the dam that goes over the spillway.[339] Both of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). However, the likelihood that adult spring run Chinook salmon ascending the fish ladder will fall back below the dam often increases with the volume of spill (Boggs et al. 2004). Increased fallback with spill remains a concern given the presence of predatory mammals in the tailrace. Fallback reascension rates of PIT tagged LCR spring

[339] At Bonneville Dam, juvenile spring Chinook survival rates through the various passage routes under tested operational conditions are generally: turbines and spillway < PH1 surface passage route (sluiceway) < PH2 juvenile bypass system and surface passage route (corner collector). Increasing spill would be expected to decrease travel time to the extent fish are moved from turbine units to the spillway, but could decrease direct survival rates to the extent fish are moved from surface passage routes or the juvenile bypass system. A reduction in direct survival will not have a negative effect on the ESU if reduced powerhouse passage results in reduced delayed mortality as predicted by CSS (2020).

Chinook at Bonneville Dam averaged 4.2 percent from 2006 to 2019. In 2018 and 2019, adult spring Chinook PIT reascension rates did not deviate substantially from the average, even with the above-average flow and spill in those years, with reascension rates of 6.9 and 3.5 percent, respectively (DART 2020c).

Early studies found that 11 to 15 percent of juvenile Chinook salmon passing through the turbines at Bonneville Dam died (Bell et al. 1967, as cited in Whitney et al. 1997). Work was done to improve the facility for downstream juvenile passage; research from 2010 and 2011 found that passage route survival estimates ranged from 93.5 percent (spillway in 2010) to 99.4 percent (Powerhouse 2 corner collector in 2011) (Ploskey et al. 2012). Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

2.10.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult LCR Chinook salmon is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of LCR Chinook salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead survival is a concern; because of temperature standard exceedances, portions of the lower Columbia River are on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges such as cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam, except The Dalles Dam. Biological monitoring shows that the incidence of observable GBT symptoms remains between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[340] Under recent operations (2008 to 2019), elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June. Monitoring data from 1998 to 2018 indicate that TDG did not increase instantaneous mortality rates for juvenile yearling Chinook in the CRS (CSS 2019).

[340] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

2.10.2.3.1 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of LCR Chinook salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[341] with enhanced inspection protocols and prepares annual oil accountability reports that record

[341] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[342] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials).

[342] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river

The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.10.2.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adults that are migrating past the dams or overwintering within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Relatively low numbers of rearing or migrating juvenile LCR Chinook salmon may have been affected by these activities, but the majority of migrants have not been affected because they predominantly migrate outside of scheduled maintenance periods.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile LCR Chinook salmon. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small. The impact of unscheduled maintenance on juvenile and adult fish has likely resulted in increased TDG exposure, passage delay, and some mortality during some outages, but measures to reduce these impacts such as quickly restoring FPP protocol, prioritizing adjacent available turbine units, and providing additional attraction to other passage routes have minimized the impacts.

2.10.2.5 Tributary Habitat

Tributary habitat conditions for the LCR Chinook salmon ESU have in general been significantly degraded by an array of land uses, including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions (contributing to stream channel simplification, reduced bank stability, increased sediment load, and elevated water temperatures) (NMFS 2013b, 2016i). In addition, tributary dams have blocked or impeded passage and access to historical habitat for LCR spring Chinook salmon populations in the Cowlitz, Lewis, White Salmon, Hood, Sandy, and Clackamas subbasins, and for LCR fall Chinook salmon populations in the Cowlitz, White Salmon, Hood, and Sandy subbasins. These dams are no longer a factor in the Hood, White Salmon, and Sandy subbasins since removal of Powerdale Dam (on the Hood River, in 2010), Condit Dam (on the White Salmon River, in 2012), and Marmot and Little Sandy Dams (on the Sandy River, in 2008). Five populations in this ESU historically spawned above Bonneville Dam, so adults and juveniles from those populations must pass Bonneville Dam; in addition, the reservoir created when the dam was completed in 1938 inundated considerable portions of historical spawning and/or rearing habitat at the mouths of tributaries for the Upper Gorge population, with some inundation also likely for the Hood and White Salmon fall Chinook salmon populations (NMFS 2013b).

Numerous tributary habitat protection and restoration actions have been implemented in recent years by local recovery planning groups, Federal and state agencies, tribal governments, local governments, conservation groups, private landowners, and other entities. These efforts have led to some local improvements in tributary habitat conditions (NMFS 2016i). However, degraded habitat conditions throughout the range of LCR Chinook salmon, particularly with regard to channel complexity, side channel and floodplain connectivity, water-quality and hydrologic patterns, and toxic contamination from exposure to emerging and legacy chemicals, continue to negatively affect the abundance, productivity, spatial structure, and diversity of LCR Chinook salmon populations (NMFS 2016i). Continued land development and habitat degradation, in combination with the potential effects of climate change, may present a continuing strong negative influence (NWFSC 2015).

2.10.2.6 Estuary Habitat

The Columbia River estuary provides important migratory and rearing habitat for LCR Chinook salmon populations. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the estuary have been lost to diking, filling, and bank hardening, combined with hydrosystem flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for subyearling Chinook salmon and reduced the production of wetland macrodetritus that supports salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review, have improved access and connectivity to floodplain habitat (NMFS 2016i). From 2007 through 2019, restoration sponsors implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents a more than a 2.5 percent net increase in a connectivity index for habitats that are used extensively by subyearling LCR Chinook salmon (Johnson et al. 2018, PNNL and NMFS 2018, 2020). Although yearling LCR Chinook salmon migrants are less likely to enter and rear in these areas, the large amounts of prey (particularly chironomid insects) exported from restored wetlands to the mainstem are actively consumed by both yearling and subyearling smolts. The resulting growth by these fish likely contributes to survival at ocean entry (PNNL and NMFS 2020). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

As discussed in Section 2.10.2.3 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, the levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, and they are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.10.2.7 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect natural populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Hatchery production for LCR Chinook salmon has reduced the diversity and productivity of natural populations throughout the ESU. NMFS directs Federal funding to many of the hatchery programs that affect the LCR Chinook salmon ESU through the Mitchell Act. NMFS completed a biological opinion on its funding of the Mitchell Act program in 2017 (NMFS 2017i). As a result, several new hatchery reform measures have been or will be implemented, as described below. The implementation of these reform measures is expected to improve the status of the ESU.

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could potentially be affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs, along with the installation of six new seasonal weirs in some tributaries, will reduce the number of hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk. The production-level changes will reduce the pHOS,[343] as described in Table 2.10-3, and reduce genetic and ecological risk.

[343] Percent hatchery fish on the spawning grounds.

- Upgrades to hatchery facilities to bring water-intake screens into compliance with new standards that ensure they minimize adverse impacts to ESA-listed fish.

Even with these improvements, hatchery production will continue to limit the diversity and productivity of natural production of LCR Chinook salmon. In addition, LCR Chinook salmon are affected by hatchery production of salmon and steelhead from other ESUs and DPSs. Hatchery programs were designed to conserve vital genetic resources and to supplement harvest levels to compensate for losses throughout the life cycle. Some scientists suspect that closely spaced releases of hatchery fish from all Columbia River basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2006) and the Lower Columbia Fish Recovery Board (LCFRB 2010) identified competition for food and space among hatchery-origin and natural-origin juveniles in the Columbia River estuary as a critical uncertainty. ODFW (2010) acknowledged this uncertainty, but listed competition for food and space as a secondary limiting factor for juveniles of all populations.

Table 2.10-3. Expected genetic effect levels on LCR Chinook salmon populations potentially affected by Mitchell Act-funded hatchery programs. Expected pHOS levels are based on a four-year average. Primary populations are targeted for viability, meaning high or very high persistence probability. Contributing populations are targeted for some improvement in status so that the MPG-wide average viability is 2.25 or higher.

Major Population Group	Population	Recovery Designation	Recent Average pHOS (2010–2015)	Expected pHOS Levels Once Mitchell Act Reforms Are Fully Implemented
Coast	**Elochoman/Skamokawa**	Primary	79%	≤50%
	Mill/Germany/Abernathy	Primary	89%	≤50%
	Grays/Chinook	Contributing	73%	≤50%
Cascade	**Coweeman**	Primary	15%	≤10%
	Lower Cowlitz	Contributing	27%	≤30%
	Toutle	Primary	64%	≤30%
	Kalama (fall)	Contributing	84%	≤10%
	Kalama (spring	Contributing	~0%	≤10%
	Lewis	Primary	34%	≤10%
	Washougal	Primary	65%	≤30%

2.10.2.8 Recent Ocean and Lower River Harvest

In February 2018, NMFS signed the 2018 to 2027 *U.S. v. Oregon* Management Agreement, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. The decision was based on both our recently completed Final EIS and the associated biological opinion (NMFS 2018a). As a result, fisheries affecting LCR Chinook salmon in the 2018 to 2027 *U.S. v. Oregon* Management Agreement are aligned with the recovery strategies in the recovery plan (NMFS 2013b).

Mark-selective fisheries are used below Bonneville Dam to focus on the retention of hatchery fish produced for harvest purposes. The impacts of these fisheries to the natural-origin spring-run populations in the ESU in the winter, spring, and summer seasons are low, with an expected harvest rate ranging from 0.2 to 2.0 percent.

Three of the spring Chinook salmon populations in the Cascade Spring MPG—the Upper Cowlitz, Tilton, and Lewis populations—are supported by associated hatchery programs, as dams currently block passage to most, if not all, of their historical spawning and rearing habitat. Therefore, the genetic legacies of these three populations are still housed in hatchery programs. In the 2018 biological opinion on the 2018 to 2027 *U.S. v. Oregon* Management Agreement, NMFS concluded that it is appropriate that harvest be managed to ensure that hatchery escapement goals are met, thus protecting what remains of the genetic legacy of the ESU (NMFS 2018a). This approach is consistent with the recovery plan, which calls for comprehensive solutions for populations with multiple issues, such as spawning access, hatcheries, and harvest (NMFS 2013b). In the Gorge MPG, NMFS (2018a) indicated that the proposed tributary harvest rates may not be consistent with achieving recovery goals once populations are reintroduced, habitat improvements are made, and the populations are no longer reliant on hatcheries for their continued survival. However, given the current reliance on the hatchery supplementation program for Hood River spring Chinook salmon and the lack of harvest on the currently extirpated White Salmon population, NMFS concluded that the proposed fisheries are adequately protective of the Gorge Spring MPG populations (NMFS 2018a).

LCR fall-run (tule)[344] Chinook salmon are managed according to an abundance rate schedule for a total escapement rate that ranges from 30 to 41 percent. The harvest schedule applies to all ocean and inriver fisheries below Bonneville Dam. In 2018, we acknowledged this as a conscientious approach that ensures the gains that have been made in VSP scores in the past few years continue to accrue.

Similarly, by continuing to limit inriver fisheries to an escapement goal of 5,700 spawners for the North Fork Lewis population, the principal indicator stock for management of the bright component of the ESU, we expect to retain the VSP scores indicating an improved viability over the next 10 years. Since 2008, escapements have averaged 11,400, exceeding both the maximum sustained yield escapement goal and the delisting abundance goal for the North Fork Lewis population.

LCR spring Chinook salmon are caught incidentally in ocean fisheries, primarily off the Washington coast and as far north as Southeast Alaska. In spring season fisheries, they are caught in the Columbia River mainstem and tributaries. Exploitation rates have declined, with rates for the Cowlitz spring Chinook salmon population declining to 27 percent since 2005.

LCR fall-run (tule) Chinook salmon are caught in ocean fisheries off the coasts of Oregon, Washington, and British Columbia. In fall freshwater fisheries, they are caught in the Columbia River mainstem and tributaries. Since 2012, they have been managed subject to an abundance

[344] Historically, the Oregon portion of the ESU contained 12 populations: nine fall run Chinook (tule); one late fall run Chinook (brights); and two spring run Chinook. Only two of these populations show substantial natural production.

rate schedule for a total exploitation rate that ranges from 30 to 41 percent. Recent exploitation rates have been highly variable but have averaged 37.2 percent since 2008.

Exploitation rates[345] have also declined for the North Fork Lewis bright population, averaging 43 percent since 2000, while the escapement rates, as noted above, exceed the goal for harvest management of 5,700 escapements.[346] This goal is based on estimates of the escapement needed to achieve maximum sustained yield. Thus, even though harvest loss is higher for this population than others in this ESU, harvest actions continue to pass more fish through the fisheries than the delisting abundance goal would require.

Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are able to estimate the total adult survival rates with substantial accuracy, we are still not able to determine the degree to which each factor contributes to mortality. However, we continue to measure and account for loss in Bonneville Reservoir and incorporate its effect in the environmental baseline.

2.10.2.9 Predation

A variety of avian and fish predators consume juvenile LCR Chinook salmon on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. This section discusses predation rates and describes management measures to reduce the effects of the growth of predator populations within the action area.

2.10.2.9.1 Avian Predation

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including LCR Chinook salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juvenile salmonids per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island, where marine forage fish were available to diversify the terns' diet. Roby et al. (2017) estimated that terns on East Sand Island consumed an average of 5.1 million smolts per year, a 59 percent reduction from when the colony was on Rice Island.

[345] Exploitation rate is the proportion of the total number of fish from a given natural-origin population(s) or hatchery stock(s) that die from the result of fishing activity in a given year.

[346] The number of salmon returning to the spawning grounds.

More recently, Evans and Payton (2020) estimated Caspian tern predation rates for the LCR Chinook salmon ESU, specifically. Average annual tern predation rates were reduced from 4.1 percent during the pre-management period to 2.5 percent post-, a statistically credible difference (Evans and Payton 2020) (Appendix B). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on LCR Chinook salmon in 2003 to 2014 was very high (27.5 percent). Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[347] where smolts are likely to constitute a larger proportion of the cormorants' diet. The average annual predation rates on LCR Chinook salmon reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (8.7 percent during 2015 to 2017 and 7.3 percent in 2018) therefore cannot be directly compared to those before management began, and are likely to underestimate predation rates in the estuary (Appendix B).

In the hydrosystem reach, the Action Agencies have employed wire arrays, pyrotechnics, water cannons, and other measures, including limited lethal take of birds at project tailraces in the lower Columbia River. These measures have been shown to reduce predation rates on juvenile salmonids at John Day and The Dalles Dams, and may have had similar effects at Bonneville Dam (Zorich et al. 2012).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on LCR Chinook salmon after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts over estimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

[347] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead; and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different but related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., had no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, it is NMFS' position that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after management measures are in place, the higher the likelihood we are able to influence adult returns (an additive effect). But the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, will also be important.[348]

With respect to management of terns in the estuary, Caspian terns nesting on East Sand Island were eating an annual average of 4.1 percent of the juvenile LCR Chinook salmon outmigrants before management actions reduced the size of that colony, and 2.5 percent per year thereafter (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (4.1 percent), the average 1.6 percent per year decrease achieved by reducing the size of the tern colony, and that some level of compensation is likely to have occurred in the ocean even in favorable ocean years, it is likely that this management measure did not lead to increased adult returns for LCR Chinook salmon. For double-crested cormorants, reduction of the colony on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 27.5 percent to 7.3 percent, a large decrease. However, in this case, predation rates on LCR Chinook salmon are likely to have increased because thousands of birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[349]

[348] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

[349] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

2.10.2.9.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). From 2015 to 2019, an annual average of 43 adult, 18 jack, and 104 juvenile Chinook salmon were incidentally caught in the Sport Reward Fishery (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were LCR Chinook salmon.

In addition to the Sport Reward Fishery, the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019. Anglers only caught one adult Chinook salmon per year from 2015 through 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). During these same years, the Dam Angling Program has removed an average of 2,792 northern pikeminnow from The Dalles Dam tailrace alone, but since the LCR Chinook salmon ESU only includes populations found below The Dalles Dam, this program is not likely to provide much benefit to juvenile LCR Chinook salmon.

Juvenile salmonids are also consumed by nonnative fishes, including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these fish, both in the lower Columbia River and Bonneville Reservoir may incrementally improve juvenile Chinook salmon survival.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile Chinook salmon, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts.

Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. In 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP. These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal remains unclear. However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the Chinook salmon that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity for LCR Chinook salmon. As such, it likely continues to benefit the ESU.

2.10.2.9.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions, Steller sea lions, and harbor seals all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace Bonneville Dam. ODFW counted the number of individual California sea lions hauling out in the Columbia River mouth at the East Mooring Basin in Astoria, Oregon, from 1997 to 2017. Individual pinniped counts at East Mooring Basin have steadily increased since the inception of the observation program with rapid increases within the last decade (Wright 2018). Within the Columbia River, the abundance of pinnipeds peaks in the spring when the spring- run stocks of LCR Chinook salmon adults are migrating through the estuary.

California sea lions and Steller sea lions aggregate each spring at the base of Bonneville Dam (and below Willamette Falls on the lower Willamette River), where they feed on adult salmon and steelhead. In 2016, the Corps documented the second-largest number of pinnipeds at Bonneville Dam and the second-largest estimate of salmonid predation since observations began in 2002: 9,525 fish, or 5.8 percent of adult salmonid passage between January 1 and May 31 (Tidwell et al. 2020). Recent declines in pup production and survival suggest the California sea lion population may have stopped growing. Numbers of Steller sea lions have been increasing between August and December in recent years (from an average of three per day in October 2011 to 22 per day in 2015) (Madson et al. 2017) and are assumed to intercept adult LCR Chinook salmon. The fall-run stocks of LCR Chinook salmon are at greatest risk when migrating near

Bonneville Dam, since their run timing coincides with the period when increasing numbers of Steller sea lions have been congregating near the dam and consuming adult salmonids. Tidwell et al. (2019) estimated that 0.7 percent of fall Chinook from all ESUs attempting to pass Bonneville Dam were consumed in 2018.

NMFS' NWFSC began studying the losses of adult spring- and summer-run Chinook salmon to sea lions between the mouth of the river and Bonneville Dam in 2010. Average annual survival through this reach has ranged from 46 to 80 percent (Rub et al. 2018), and up to 50 percent of the mortality of adult spring- and summer-run Chinook salmon destined for tributaries above Bonneville occurred within the 10-mile reach just below the dam.

Adult LCR Chinook salmon are vulnerable to pinniped predation throughout the lower Columbia River. This vulnerability is experienced primarily by the nine spring-run populations that migrate during May and June, when the pinnipeds' abundance is highest. Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019 respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the mainstem of the Columbia River between RM 112 and McNary Dam (RM 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

2.10.2.10 Research, Monitoring, and Evaluation Activities

The primary effects of the past and present CRS-related RME programs on LCR Chinook salmon are those associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through establishing a better understanding of the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were LCR Chinook salmon. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the LCR Chinook salmon ESU by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of LCR Chinook salmon that have been handled (or have died) each year during the implementation of RME as the average annual take reported for 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of LCR Chinook salmon associated with the Smolt Monitoring Program and the CSS were as follows:
  - Zero hatchery and 6,363 natural-origin juveniles were handled (none died).

- Average annual estimates for LCR Chinook salmon handling and mortality for all other RME programs:
  - 21 hatchery and 11 natural-origin adults were handled.
  - One hatchery and one natural-origin adult died.
  - 97 hatchery and 3,490 natural-origin juveniles were handled.
  - One hatchery and 15 natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) of LCR Chinook salmon associated with these elements of the RME program has, on average, affected less than 1 percent of the natural-origin adult (recent, 5-year average) run (arriving at the Columbia River mouth) and less than 1 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects LCR Chinook salmon.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the ESU level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.10.2.11 Critical Habitat

The condition of LCR Chinook salmon critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized here in Table 2.10-4. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for LCR Chinook salmon production have been weakened. Conditions in the portion of the hydrosystem designated as critical habitat (i.e., the mainstem Columbia River below the confluence of the Hood River) were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for LCR Chinook salmon have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.10-4. Physical and biological features (PBFs) of designated critical habitat for LCR Chinook salmon**.**

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development.	Tributary barriers (culverts, dams, water withdrawals) have reduced the availability of freshwater spawning sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for all populations. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning sites for all populations. Some improvement in riparian, channel, and floodplain conditions in the lower ends of tributaries where large dams have been removed (e.g., White Salmon, Hood, and Sandy Rivers) has improved the quality of freshwater spawning sites for some populations. Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) has reduced water quality in freshwater spawning sites for all populations. Inundation of the lower reaches of tributaries to Bonneville Reservoir has limited the availability of fall-run Chinook salmon spawning sites for three of 32 populations (hydrosystem development). We do not know how much spawning habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is likely to be available within the 5-foot operating range. Many tributary habitat improvement actions implemented in the lower Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to improve habitat complexity and

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		riparian area condition, reduce fish entrainment, and remove barriers to spawning habitat. For the three fall-run LCR Chinook salmon populations in the upper portion of the Columbia Gorge MPG, inundation of the lower reaches of tributaries to Bonneville Reservoir has limited the availability of freshwater spawning habitat (hydrosystem development). We do not know how much spawning habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is likely to be available within the 5-foot operating range.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, and natural cover.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater rearing sites for many populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations. Excessive sediment in streambed (unimproved roads, forest and agricultural practices) has reduced the quality of freshwater rearing sites for all populations. Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) have reduced water quality in freshwater rearing sites for many populations. The Corps has developed best management practices to avoid accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable lubricants" where feasible. Inundation of the lower reaches of tributaries to Bonneville Reservoir has limited the availability of freshwater rearing habitat for five of 32 populations (hydrosystem development). We do not know how much rearing habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is likely to be available within the 5-foot operating range.
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover.	Alteration of the seasonal flow regime in the lower Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderate negative effect in lower flow years for all populations. Alteration of the seasonal mainstem temperature regime in the lower Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in late summer and fall (hydrosystem development and operations).[1] This has negatively affected the functioning of water quality in the juvenile and adult migration corridors for the latest migrating subyearling smolts and the earliest migrating adult fall-run Chinook salmon from all populations. Reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (hydrosystem development) may have reduced "natural cover" in the migration corridor for all populations. Increased exposure of juveniles to TDG (water quality) in The Dalles and Bonneville Reservoirs and at least 35 miles below Bonneville Dam during involuntary and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor for juveniles and spring-run adults from populations in the Gorge MPG. The incidence of adverse effects (GBT in juveniles and adults) appears to have been small in recent years (1 to 2 percent). Fall-run adult Chinook salmon are not exposed to elevated TDG associated with spring spill. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining) affects all populations. The Corps has developed best management practices to avoid accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable lubricants" where feasible. Delay and mortality of juveniles and adults from Gorge populations at Bonneville Dam (hydrosystem development and operations) has increased obstructions in the migration corridor for five of 32 populations. However, obstructions have been substantially reduced for juveniles with the construction of surface passage

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult Chinook salmon during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past Bonneville, Dam). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile Chinook salmon because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include repair of the spillway apron at Bonneville Dam and overhauling the juvenile bypass system. Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for predators, especially birds (juveniles) and pinnipeds (adults) in the tailrace of Bonneville Dam (excessive predation) for Gorge populations. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, and propane cannons. Pinniped predation is addressed by the use of sea lion excluder devices and for spring-run adults, hazing at the fishway entrances at Bonneville Dam.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, juvenile and adult forage.	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production and the quantity and quality of estuarine rearing areas for all populations. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling Chinook salmon by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids that are used by terns and cormorants for nesting) have created excessive predation for all populations. Implementation of the Caspian Tern Management Plan on East Sand Island is reducing excessive predation on juvenile Chinook salmon, but, depending on ocean conditions and compensatory effects, may not be increasing adult returns for LCR Chinook salmon. Implementation of the Double-crested Cormorant Management Plan may have contributed to, or at least coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island. Observations of increased pinniped predation and risk for adults from spring-run populations.
Nearshore marine areas[2]	Free of obstruction and excessive predation with water quality, quantity, and forage.	Concerns about increased pinniped predation and adequate forage. Reduced quality of nearshore marine areas.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.10.2.12 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of LCR Chinook salmon, including recent biological opinions issued for the LCR Chinook salmon and key emergent or ongoing habitat concerns (NMFS 2016i). From January 2015 through May 22, 2020, we completed 518 formal consultations that addressed effects to LCR Chinook salmon.[350] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects

[350] PCTS data query, July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some restoration actions may have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (typically less than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects. All of these actions have undergone section 7 consultation, and the actions or the RPAs were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.10.2.13 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of LCR Chinook salmon populations. Recent improvements in passage conditions at Bonneville Dam and at tributary barriers, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. NMFS (2016i) identified past land development, habitat degradation, and predation, in combination with the potential effects of climate change, as limiting factors that continue to negatively affect LCR Chinook salmon populations.

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for LCR Chinook salmon, as described above. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in the last two decades to improve the functioning of some of these PBFs of critical habitat. For example, surface passage structures and spill operations have reduced obstructions for juvenile LCR Chinook salmon from the five populations that pass Bonneville Dam. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. For subyearling smolts, restoration projects in the estuary are improving the functioning of areas used for growth and development. However, the factors described above continue to have negative effects on these PBFs.

2.10.3 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the Federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.10.3.1 Effects to Species

The proposed action will implement flexible spring spill operations at the lower Snake River and lower Columbia River mainstem dams in an attempt to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns.[351] Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG ("gas cap spill") for a minimum of 16 hours per day, and may operate under "performance standard spill" for up to 8 hours per day. John Day Dam will spill up to120 percent TDG for 16 hours per day, with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs spill constraint) and 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

[351] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in these periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under the higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.10-5.

Table 2.10-5. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 16 to August 31 at the four lower Columbia River projects (Table 2.10-6). Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.10-6. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.10-6. Proposed summer spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[2]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March; decreased flows from May through August, and little change in flows in April and September) described in the environmental baseline will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby Dam and Hungry Horse Dam operations are intended to benefit resident species. The change in Libby Dam operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce winter spill events (and associated elevated TDG levels), which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries when TDG is excessive. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.10-4).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

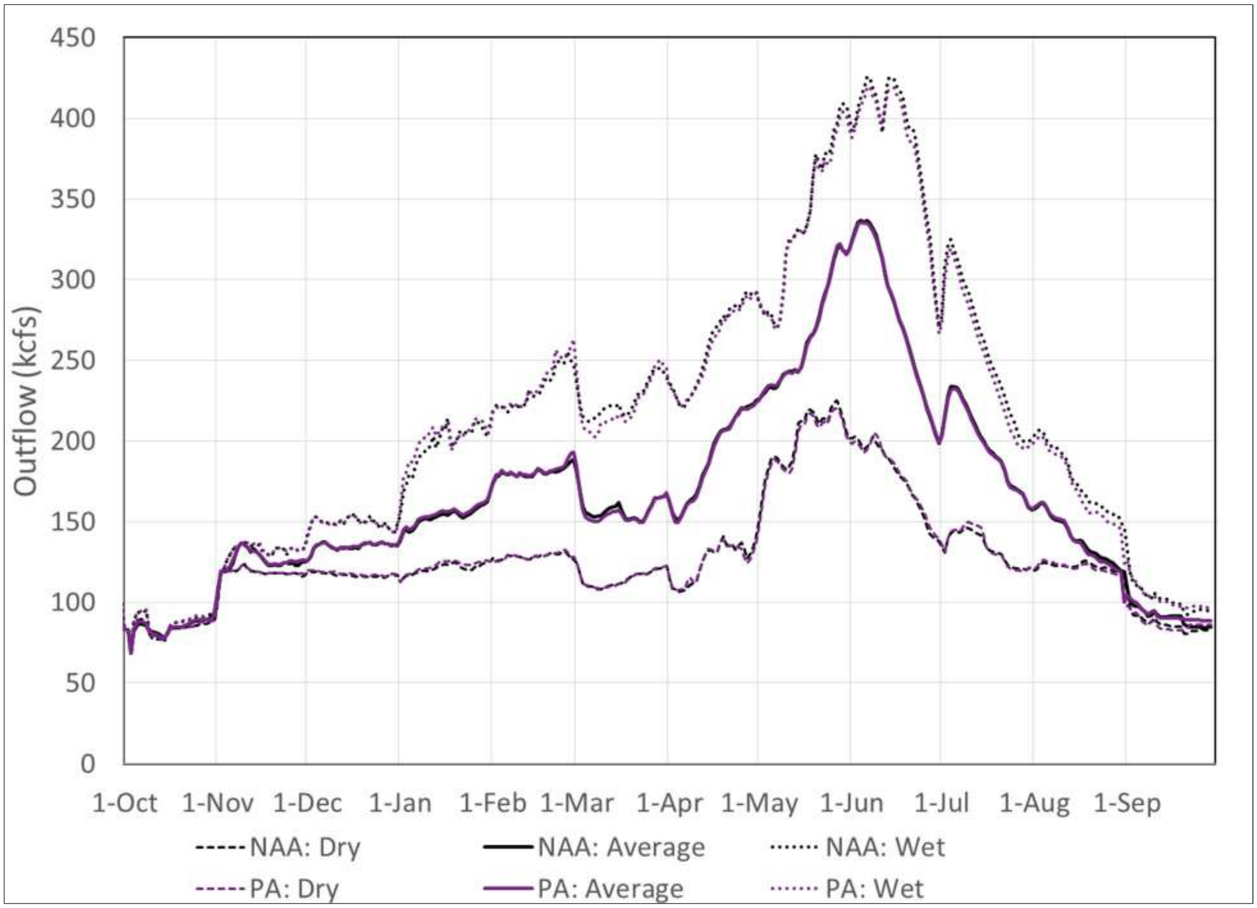

Figure 2.10-4. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

These proposed changes in reservoir operations are not likely to meaningfully affect the probability of meeting spring or summer flow objectives, and associated effects on LCR Chinook smolts or adults by a meaningful amount.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[352] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges

[352] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on LCR Chinook salmon are likely to be very small and are not expected to detectably affect reach survival estimates.

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency hypothetically increases the exposure of LCR Chinook salmon juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile LCR Chinook salmon typically spend days to weeks in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

The effects of the proposed hydrosystem operations and the non-operational measures on LCR Chinook salmon and its habitat are described below.

2.10.3.1.1 Hydrosystem Operation

For LCR Chinook salmon, the effects of operating the hydrosystem include continued utilization of recent passage improvements that have increased the survival of yearling (spring) and subyearling (fall) Chinook salmon that pass through Bonneville Dam (Upper Gorge Fall Run, White Salmon Fall Run, White Salmon Spring Run, Hood River Fall Run, and Hood River Spring Run populations): improved sluiceway (fish guidance efficiency and survival) at Powerhouse 1, minimum gap runner turbines at Powerhouse 1 (survival), and improved screens and turbine unit operations at Powerhouse 2 (survival). After all these improvements were functioning, Ploskey et al. (2011) and Skalski et al. (2012) estimated juvenile dam passage survival for yearling Chinook salmon to be 95.2 percent (SE = 0.4 percent) in 2010 in a single release study, and 96.0 percent (SE = 1.8 percent) in 2011 in a virtual paired release study, respectively. Subyearling fall Chinook survival was estimated to be 97.4 percent in 2012, with 30 percent of the fish going through turbines (BPA et al. 2020).

We estimate upstream survival rates of adult LCR Chinook salmon using surrogate PIT-tag detections of Snake River spring/summer and fall Chinook salmon at Bonneville Dam (i.e., for fish that were later redetected at an upstream dam) of 96.3 for spring-run and 98.4percent for fall-run fish. Surrogates are necessary since adult LCR Chinook do not typically migrate between two detection points (i.e., Bonneville to The Dalles) to be able to estimate survival. Under the proposed action, we expect there will be higher spillway passage rates for both juvenile and adult LCR Chinook salmon passing Bonneville Dam but direct survival will be similar to that described in the Environmental Baseline section during the performance level spring spill condition.

During periods of increased spring spill, the effects to LCR Chinook salmon include: 1) potential for increased fallback of adults for the two spring-run populations that spawn upstream of Bonneville Dam (White Salmon Spring Run and Hood River Spring Run),[353] 2) juveniles from populations that migrate downstream from April 10 to June 15 will be more likely to pass through the spillway and less likely to pass through the Powerhouse 2 turbines, juvenile bypass system, corner collector, or Powerhouse 1, and 3) exposure to increased levels of TDG (up to 125 percent) as a result of the flexible spring spill operation in Bonneville Reservoir and downstream of the dam for at least 35 miles. The Dalles will operate to 40 percent spill, and TDG levels will be similar to recent conditions.

High spill is correlated with fallback behavior at Bonneville Dam for Chinook salmon, which can increase the risk of mortality, injury, and fatigue (Boggs et al. 2004). Adult fallback can also increase exposure to pinnipeds when they are present at the dam. High spill up to 150 kcfs at Bonneville Dam would most likely affect the two populations of LCR Chinook salmon (White Salmon Spring Run and Hood River Spring Run) that migrate upstream of Bonneville Dam during the spring, or individual fish from other populations that overshoot nearby tributaries.

[353] Adults from the three fall-run populations that migrate above Bonneville Dam will not be in the river during the flexible spring spill operation.

Similarly, because smolt survival rates are lower through the spillway at Bonneville Dam than through several other routes of passage, increased passage rates through the spillway, in comparison to the juvenile bypass system or corner collector at Powerhouse 2, for example (Ploskey et al. 2012), are likely to result in slightly decreased survival rates compared to recent operations. However, the CSS hypothesizes that increased spill will substantially reduce latent mortality of Snake River spring/summer Chinook salmon populations moving downstream through the mainstem dams (FPC 2020). Only a fraction of this hypothesized benefit could potentially be realized for LCR spring Chinook salmon populations upstream of Bonneville Dam (passing only one mainstem dam), if realized, it would slightly improve overall survival and productivity.

Compared to recent hydropower operations,[354] increased spill levels from April 10 to June 15 will increase the exposure of adult spring migrating adults and smolts to higher concentrations of TDG. The increased exposure is likely to affect the five populations within Bonneville Reservoir and the populations nearest to Bonneville Dam, though increased TDG levels will be measurable for at least 35 miles downstream of the dam. Exposure to elevated TDG (up to 125 percent TDG) levels as a result of increased juvenile fish passage spill may affect individual smolts but should have little, if any, substantive effect on juveniles migrating swiftly past Bonneville Dam and its tailrace because of some depth compensation and the brevity of exposure. Adults could be exposed for hours or days to elevated TDG levels as they seek out fishway entrances in the tailrace of Bonneville Dam. However, the potential impacts of exposure up to 125 percent TDG levels are likely to be very limited due to depth compensation.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures. Maintenance of fish ladders, screens, bypass systems, and turbine units will occur along with some dredging and rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of LCR Chinook present and these effects will occur at extremely low levels similar to what was observed in the recent past. Maintenance schedules have been developed through FPOM to avoid impacts and may be modified if evidence indicates elevated delay and mortality are occurring. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults, but alternative measures as coordinated in FPOM (e.g., alternative spill or turbine unit priorities) and the efficient return FPP protocol will likely minimize these impacts.

The proposed operations at Libby Dam, Hungry Horse Dam, and Grand Coulee Dam should not measurably affect juvenile and adult survival because the flow alterations in the Columbia River

[354] From 2008 to 2017, the hydropower operation targeted 100 kcfs spill. In 2018, spill levels were increased to the 120 percent TDG limit (in the tailrace of Bonneville Dam).

are relatively small. The small reduction of flow would not be sufficient to affect river temperature, which would be the most relevant effect influencing survival. The proposed operation at Dworshak Dam is not expected to affect migrating LCR Chinook because it occurs only during high flow years and is outside of their migration corridor. Any potential flow reduction would only occur in high flow years and thus not add risk to migrating LCR Chinook. The proposed operation at Grand Coulee Dam will have a very slight effect on flow, primarily in August, and should not affect migration or survival.

The other proposed changes to CRS operations are not anticipated to negatively affect LCR Chinook salmon survival. In particular, the proposed continuation in usable forebay ranges (MOP 1.5-foot range) at the lower Snake River reservoirs and the increase in operating range at the John Day forebay to address Blaylock Island predation, will result in inconsequential variations in the timing and amount of flow in the lower Columbia River.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for adult and juvenile salmonids passing through the turbine units, but the number of LCR Chinook salmon affected should be extremely low. Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure and improve ladder attraction conditions for adult LCR Chinook salmon, but would also slightly reduce turbine unit survival for adult and juvenile salmonids passing through the turbine units, and would also increase powerhouse passage rates for juveniles. These flow levels would be expected to occur in up to 5 to 10 percent of the years at Bonneville Dam; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur. Operating turbine units above the 1 percent efficiency resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is an average of 8 to 30 hours per project, with a maximum of 8 to 80 hours per project, for lower Columbia River dams, from April through June. Increased flows through the units as a result of these operations should be about 500 cfs, or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation and, thus, likely overestimates the duration that would actually be implemented. Overall adult survival rates of LCR Chinook salmon originating or migrating above Bonneville Dam in the spring should not be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of LCR Chinook salmon through Bonneville Dam, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

2.10.3.1.2 Predation Management and Monitoring Actions

The Corps' program to install and operate sea lion excluder gates at Bonneville Dam each year will continue[355] and is likely to positively affect the five populations that pass upstream of Bonneville Dam. Likewise, the Corps' and BPA's support of spring and fall sea lion hazing, dissuasion, and removal efforts from the area downstream of Bonneville are likely to continue to substantially reduce adult mortality of LCR Chinook salmon in the spring and fall (compared to mortality rates if these actions did not continue).

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. The current fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that numbers of Chinook salmon, including some from the LCR Chinook salmon ESU, handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy) will be no more than 100 adults (including jacks) and 200 juveniles per year. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams as described in the proposed action (BPA et al. 2020). Since the likelihood of the Dam Angling Program being implemented at Bonneville Dam is not is not reasonably certain to occur, it is unlikely that the program will have an effect on the abundance of LCR Chinook salmon. We estimate that no more than 10 adult (including jacks) and 20 juvenile Chinook salmon will be caught in the Dam Angling Program per year, though these would be unlikely to include any LCR Chinook salmon. The NPMP measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A

[355] The excluder gates may be removed and reinstalled seasonally based on the presence of sea lions.

30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including LCR Chinook salmon.

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions are likely to continue current levels of predation at these colonies, which, in the case of Caspian terns, is an average annual reduction of 1.6 percent from the pre-colony management period. However, ocean conditions, including compensatory effects such as the number and behavior of predators and competition for prey, will determine whether or not this reduction in tern predation influences adult returns. Although there appears to have been a substantial decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 27.5 percent before colony management to 7.3 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, we expect that cormorant predation in the estuary may be an increasingly important source of mortality for LCR Chinook salmon.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none have been proposed at this time.

The Action Agencies will also continue to implement, and improve as needed, the avian predation deterrence measures at the tailraces of lower Columbia River dams, which address another source of mortality for juvenile LCR Chinook salmon emigrating from populations in Bonneville Reservoir. These measures will continue to reduce predation on juvenile Chinook salmon, although Zorich et al. (2012) were unable to quantify the amount of protection.

2.10.3.1.3 Habitat Actions

For the LCR Chinook salmon populations that have been negatively affected by CRS operations and maintenance, the Action Agencies will provide funding and/or technical assistance for tributary habitat improvement actions consistent with recovery plan implementation priorities and other regional efforts, as funding allows. If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could benefit the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for LCR Chinook salmon as part of this proposed action, or proposed such actions in a manner that would allow us to meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential projects in our jeopardy analysis.

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and improve access to these resources for juvenile salmonids. Estuary habitat conditions are especially important for LCR fall Chinook salmon, and NMFS (2013b) considered altered hydrology and flow timing in the estuary, as well as loss of side channel and wetland habitat, a primary limiting factor for this life-history component of the ESU.

The subyearling life-history type, which dominates this ESU, spends longer in the estuary (several weeks to several months) and thus is more likely to benefit from increased access to floodplain rearing habitat than the yearling life-history types produced by spring-run Chinook salmon populations. However, these habitat restoration projects are also increasing the production and flux of prey commonly consumed by yearling Chinook salmon migrating through the lower Columbia River (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020), whether or not they enter a reconnected floodplain site.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty in predicting the timing and accomplishment of habitat restoration actions and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels, etc.) to site conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about the potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway. Continued implementation of this monitoring program will either confirm that these floodplain reconnections are enhancing conditions for subyearling and yearling LCR Chinook salmon, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the availability of rearing habitat and the flux of insect and amphipod prey to the mainstem migration corridor for juvenile LCR Chinook salmon. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[356] of all LCR Chinook salmon populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.10.3.1.4 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for the impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail within the site-specific biological opinions referenced therein (see Section 2.10.2.7). Hatchery effects are also described in Appendix C of NMFS (2018), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.10.3.1.5 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult LCR Chinook are likely to be present in shallow shoreline areas, an unknown portion of the ESU will continue to be stunned, harmed or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this ESU that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages

[356] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile Chinook salmon opportunities to move into wetland habitats for food and refuge from predators. Moreover, the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the LCR Chinook salmon ESU.

will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[357]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of LCR Chinook salmon will be affected each year:

- Activities associated with the Smolt Monitoring Program and the CSS:
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - Zero hatchery and 22,800 natural-origin juveniles will be handled.
  - Zero hatchery and 456 natural-origin juveniles will die.
- Activities associated with all other RME programs:
  - 900 hatchery and 400 natural-origin adults will be handled.
  - 10 hatchery and 10 natural-origin adults will die.
  - 10,000 hatchery and 27,200 natural-origin juveniles will be handled.
  - 100 hatchery and 544 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program will, on average, affect 1.7 percent of the natural-origin adult (recent, 5-year average) run (arriving at mouth of the Columbia River) and 0.43 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to much less than 1 percent of estimated ESU abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations

357 Ongoing and future discussions are expected to lead to reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

(including facilities modifications and mitigation actions), the small effects of the RME programs on abundance are acceptable and warranted.

2.10.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small reduction in obstructions at lower Columbia River dams for individuals from five of the 32 populations of LCR Chinook salmon—Upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run. Adults from these populations that migrate during periods of gas cap spill are likely to experience a small increase in obstructions due to an increased rate of involuntary fallback over the spillways. Implementation will also affect the volume and timing of flow in the Columbia River, which alters habitat in the hydrosystem reach and Columbia River estuary. Effects of the proposed action on PBFs are listed in Table 2.10-7.

Table 2.10-7. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the LCR Chinook salmon ESU.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning sites	Continued inundation of some fall-run Chinook salmon spawning sites in the lower ends of tributaries to Bonneville Reservoir (reduced availability of sites for spawning, incubation, and larval development for three of 32 populations). We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but it is likely that none or very little of this habitat will be available within the 5-foot operating range.
Freshwater rearing sites	Continued inundation of some spring- and fall-run Chinook salmon rearing sites in the lower reaches of tributaries to Bonneville Reservoir (reduced availability of freshwater rearing site for five of 32 populations). We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but it is likely that none or very little of this habitat will be available within the 5-foot operating range. Continued reduction in quantity of rearing habitat for five populations. See also “estuarine areas.”
Freshwater migration corridors	Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies’ ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. Proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not affect the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and early summer, when juveniles and adult spring-run LCR Chinook salmon are migrating, and warmer temperatures in the summer and fall when

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	adult fall-run LCR Chinook salmon are migrating. In general, cooler spring temperatures will not adversely affect the functioning of water quality in the mainstem migration corridor for juveniles or spring-run adults. However, this will continue to adversely affect water quality in the juvenile and adult migration corridors for the earliest migrating adult LCR fall Chinook salmon and the latest migrating subyearling smolts. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (ongoing reduction in "natural cover"). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill in the gorge area and at least 35 miles downstream of Bonneville Dam during flexible spring spill. The effect on water quality in terms of an increase in the incidence of GBT is likely to be very small. The flexible spring operation to 125 percent TDG will increase obstructions in the adult migration corridor by a small amount for five populations by increasing the risk of fallback over project spillways. The flexible spring operation to 125 percent TDG will increase obstructions in the juvenile migration corridor by a very small amount by increasing the risk of fallback through a turbine or juvenile bypass facility for the five populations with spawning areas above Bonneville Dam. Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions at Bonneville Dam (reduced obstructions). However, by increasing powerhouse flows, more fish will pass downstream or fall back through a turbine unit, increasing obstructions by a small amount for juveniles and adults from the five populations with spawning areas above Bonneville Dam. Continued small increases in obstructions for adult Chinook salmon during routine outages of fishways or turbine units at Bonneville Dam. Very small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities. Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	Continued deployment of sea-lion exclusion devices and hazing at Bonneville Dam to maintain the protection of adult Chinook salmon that reach the fishways at current levels (ongoing reduction in predation). Continued implementation of the NPMP to maintain fish predation (ongoing reduction in predation) at current levels. Continued implementation of the avian predation deterrence operations to maintain predation on juvenile Chinook salmon in project tailraces at current levels (ongoing reduction in levels of predation).
Estuarine areas	Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels and juvenile and adult forage. This will increase opportunities for subyearling Chinook salmon to access sites used for growth and transition to life in the ocean and will increase access to prey for yearling Chinook that remain in the mainstem. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of smolt predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.10.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.10.1), Environmental Baseline (Section 2.10.2), and Effects of the Action (Section 2.10.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including LCR Chinook salmon.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of the activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.10.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution; or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.10.5.1 Species

The LCR Chinook salmon ESU comprises 32 independent populations, which are grouped into six MPGs based on combinations of ecoregions (Coast, Cascade, Gorge) and life-history type (spring, fall, late fall). Twenty-nine populations are rated at high or very high risk, and three populations are rated at moderate risk (Sandy River), low risk (Sandy Late-fall), or very low risk (NF Lewis Late-fall). LCR Chinook salmon are at very low population levels throughout their range (with the exception of the North Fork Lewis River and Sandy River late-fall populations), primarily due to degraded or lost access to spawning and rearing habitat in tributaries.

Five Columbia Gorge populations (two spring and three fall-run) of LCR Chinook spring run are affected by upstream and downstream passage at Bonneville Dam. However, the White Salmon and Upper Gorge fall-run populations were showing stable or improving VSP scores according to the most recent status review. Similarly, the White Salmon spring-run population demonstrated an improving VSP score. The Hood River spring and fall-run populations lacked sufficient data to fully evaluate their status. Compared to earlier estimates, the most recent estimates of population abundance (2014 to 2018 geomeans) indicate no clear trends, with some populations increasing, some decreasing, and others staying at similar levels. Recent poor ocean conditions associated with a marine heatwave and its lingering effects have likely contributed to lower than average survival rates for some populations in recent years. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants.

Structural and operational improvements at Bonneville Dam should improve passage conditions for juvenile LCR Chinook salmon from the five populations that spawn upstream of Bonneville Dam. The proposed 125 percent TDG spring spill operation should further increase spill levels at Bonneville Dam (limited to 150 kcfs), which will increase juvenile exposure to TDG beginning April 10. Other operations (e.g., upper Columbia operations to better protect resident species, Dworshak Dam winter operations to reduce TDG in the lower Clearwater River, operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, etc.) could, collectively, have a small, negative effect, especially on juvenile migrants. However, these effects should not measurably alter juvenile survival rates, and overall juvenile passage survival should be maintained or should increase slightly as a result of this proposed operation.

Maintenance of fish ladders, screens, bypass systems, and turbine units will occur along with dredging and rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of LCR Chinook present and these effects will occur at extremely low levels similar to what was observed in the recent past. Maintenance schedules have been developed through FPOM to avoid impacts and may be modified if evidence indicates elevated delay and mortality are occurring. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative spill or turbine unit priorities) and the efficient return FPP protocol will likely minimize these impacts.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving LCR Chinook salmon abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity, life-history and diversity) for all populations in this ESU. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan and the Double-crested Cormorant Management Plan, as well as hazing at Bonneville Dam. For LCR Chinook salmon, we expect that management of the East Sand Island tern colony is reducing mortality by a small amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that likely prey on juvenile LCR Chinook salmon are also present in the hydrosystem reach. The NPMP is expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested Cormorant Management Plan, these programs will maintain current (reduced) levels of predation, creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on LCR Chinook salmon in the lower Columbia River and estuary has increased substantially with recent increases in the abundance of sea lions, especially in the spring. However, estimated losses in the Bonneville tailrace have declined recently, ranging from about 3 to 5 percent since 2016. Sea lion predation downstream of Bonneville Dam, including the estuary, continues to substantially and negatively affect the productivity and abundance of LCR Chinook salmon.

The management of LCR Chinook salmon hatchery programs has improved substantially compared to historical operations. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of LCR Chinook salmon.

Harvest rates on LCR Chinook salmon in both ocean and freshwater fisheries have decreased greatly compared to historical levels, but remain substantial. Abundance based, ocean and mainstem harvest rates for spring-run and fall-run (tule) LCR Chinook salmon have generally averaged 27 percent (since 2005) and 37.2 percent (since 2008), respectively.

As described in Section 2.10.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect LCR Chinook salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of LCR Chinook salmon as moderate. We generally expect that abundance could decrease and extinction risk increase as a result of climate change.

Fall-run adults could potentially respond temporally to changing environmental conditions by migrating and spawning later in time, however spring-run adults are reliant upon spring flows, and will be exposed to higher summer temperatures. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or winter flood events). Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in streams and in the estuary. Subyearling migrants, because they typically spend little time in freshwater, would avoid exposure to higher summer temperatures, but yearling migrants would be exposed. Though the quality of information is mixed, sensitivity in the marine stage is certainly high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur.

The proposed action—the future operation and maintenance of the CRS (including upper Columbia River operations and Dworshak Dam winter operations to reduce TDG in the lower Clearwater River)—will have little overall effect on the seasonal hydrograph or seasonal temperatures compared to recent conditions. The seasonal hydrograph will continue to be altered, generally increasing flows in the fall and winter and reducing flows in the spring. Seasonal water temperatures will also continue to be altered, with delayed warming in the spring, delayed cooling in the fall, and reduced daily temperature variability. These effects to river conditions likely adversely affect the survival of LCR Chinook salmon, but to an extent not readily quantified based on the best available information.

Other operations (e.g., operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, increasing the John Day reservoir operating range during the spring to reduce avian predation, etc.) are, collectively, expected to have extremely small negative effects, especially on juvenile migrants, but these effects should not measurably alter survival through Bonneville dam and reservoir.

NMFS' life-cycle modeling (for SR spring/summer Chinook salmon), which considered three potential levels of changing climate severity over the next 24 years, clearly indicates that climate change effects, especially those that may manifest in the ocean, pose a substantial threat as they can have severe, negative consequences to the overall productivity (and abundance) of all SR spring/summer Chinook salmon populations (see Section 2.2.3.1.12 Life-Cycle Modeling), and likely to other "stream type" Chinook salmon populations as well. These climate change consequences are not caused by the proposed action. In simple terms, even if the adult abundance declines somewhat as a result of climate change, which will make recovery of this ESU somewhat more challenging, it will have declined no more so as a result of the proposed action.

The proposed action includes conservation measures to mitigate the potential adverse effects of the action, in many cases by addressing limiting factors for survival and recovery. These measures include estuary habitat improvement and predator management actions that should benefit VSP parameters, thus reducing the expected abundance declines caused by climate change. Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this ESU (e.g., dam passage survival, population productivity, degraded estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.)

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity, especially for those populations upstream of Bonneville Dam. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., estuary habitat, predation, etc.). For the five Columbia Gorge populations, evidence suggests that these actions have contributed to improved freshwater survival and improved productivity, and may improve spatial structure and diversity over time. The proposed action carries forward structural and operational improvements at Bonneville Dam since 2008 and improves upon them. Additional juvenile survival improvements are expected from the flexible spring spill operation, and ecosystem functions should continue to increase in estuary habitats where improvement actions occur.

Climate change is a substantial threat to LCR Chinook salmon, especially during the marine rearing phase of their life cycle. The proposed action should not exacerbate either the scope or severity of those impacts.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of LCR Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of LCR Chinook salmon.

2.10.5.2 Critical Habitat

Critical habitat for LCR Chinook salmon encompasses 10 subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2013b) and most of these watersheds have some, or a high, potential for improvement. The removal of some large tributary dams has improved habitat quality in spawning and rearing areas in the lower reaches of these streams and removed obstructions for spring-run LCR Chinook salmon populations with higher elevation spawning areas. Similar to the discussion above for the species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns.

The environmental baseline includes a broad range of past and present actions and activities, including effects of the hydrosystem, that have affected the conservation value of critical habitat in the juvenile and adult migration corridors for LCR Chinook salmon. Some of these past effects will continue: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and for five populations with spawning areas above Bonneville Dam, longer travel times and passage delays (obstructions in the migration corridor). These factors have increased the likelihood of excessive predation on some juvenile and adult LCR Chinook salmon and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The CRS also will continue to inundate spawning and rearing habitat (substrate) in the lower reaches of the tributaries to the Bonneville Reservoir for the three fall-run populations with spawning areas in the Columbia gorge. We do not know how much spawning habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is likely to be available within the 5-foot operating range.

The proposed action carries forward structural and operational improvements since 2008 that address some of these effects on PBFs and in some cases, improves upon them. The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors.

The Action Agencies also have reduced the effects of their operations on travel time and survival for juveniles from the Columbia Gorge populations by increasing the level of spring spill at Bonneville Dam. We expect the flexible spring spill to 125 percent TDG to reduce water quality in the juvenile and adult migration corridors by a small amount for the five populations with spawning areas above Bonneville Dam. Higher spill levels will increase obstructions for adults from these populations by a small amount due to the increased risk of fallback over the spillway.

Operating the turbine units at Bonneville and The Dalles Dams above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow events is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction conditions for adult LCR Chinook salmon from the five gorge populations. However, by increasing powerhouse flows, it will increase obstructions for adults and juveniles by a small amount because some adults will fall back or juveniles will move downstream through turbines. This operation would not affect the functioning of the juvenile and adult migration corridors below the tailrace of Bonneville Dam.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors. In summary, the proposed action is not likely to further limit water quantity or water quality or to increase obstructions in the juvenile or adult migration corridors by a meaningful amount.

The Action Agencies will continue to implement pinniped predation measures to reduce predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the lower Columbia River, and the predation management programs for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will maintain the levels of predation in the migration corridors that were achieved in recent years, although cormorant predation rates may increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the estuary, many of these funded through the CRS program. The Action Agencies propose to continue to reconnect an average of 300 acres of the historical floodplain per year, further increasing access to rearing areas used by subyearling Chinook salmon and the availability of wetland-derived prey to yearlings (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of LCR Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of LCR Chinook salmon designated critical habitat.

2.10.6 Conclusion

After reviewing and analyzing the current status of LCR Chinook salmon and its critical habitat, the environmental baseline, the direct and indirect effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR Chinook salmon or destroy or adversely modify its designated critical habitat.

2.11 Lower Columbia River (LCR) Steelhead

This section applies the analytical framework described in Section 2.1 to the LCR steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the LCR steelhead DPS or destroy or adversely modify its critical habitat.

2.11.1 Rangewide Status of the Species and Critical Habitat

The status of the LCR steelhead DPS is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.11.1.1 Status of the Species

2.11.1.1.1 Background

On March 19, 1998, NMFS listed the LCR steelhead DPS as a threatened species (63 FR 13347). The threatened status was reaffirmed on January 5, 2006 (71 FR 834), and most recently on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that this DPS should retain its threatened status (81 FR 33468). Critical habitat for LCR steelhead was designated on September 2, 2005 (70 FR 52630). The summary that follows describes the status of LCR steelhead. More information can be found in the recovery plan (NMFS 2013b) and the most recent status review for this DPS (NMFS 2016i).[358]

The LCR steelhead DPS includes all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive), and excludes such fish originating from the upper Willamette River basin above Willamette Falls. This DPS also includes steelhead from seven artificial propagation programs (71 FR 834).[359]

[358] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

[359] Cowlitz Trout Hatchery Late Winter-run Program; Kalama River Wild Winter-run and Summer-run Programs;

The DPS consists of 23 independent populations, which are grouped into four MPGs based on combinations of ecoregion (Cascade, and Gorge) and life-history type (winter-run and summer-run): Cascade Winter (14 populations), Cascade Summer (four populations), Gorge Winter (three populations), and Gorge Summer (two populations)[360] (Figure 2.11-1).

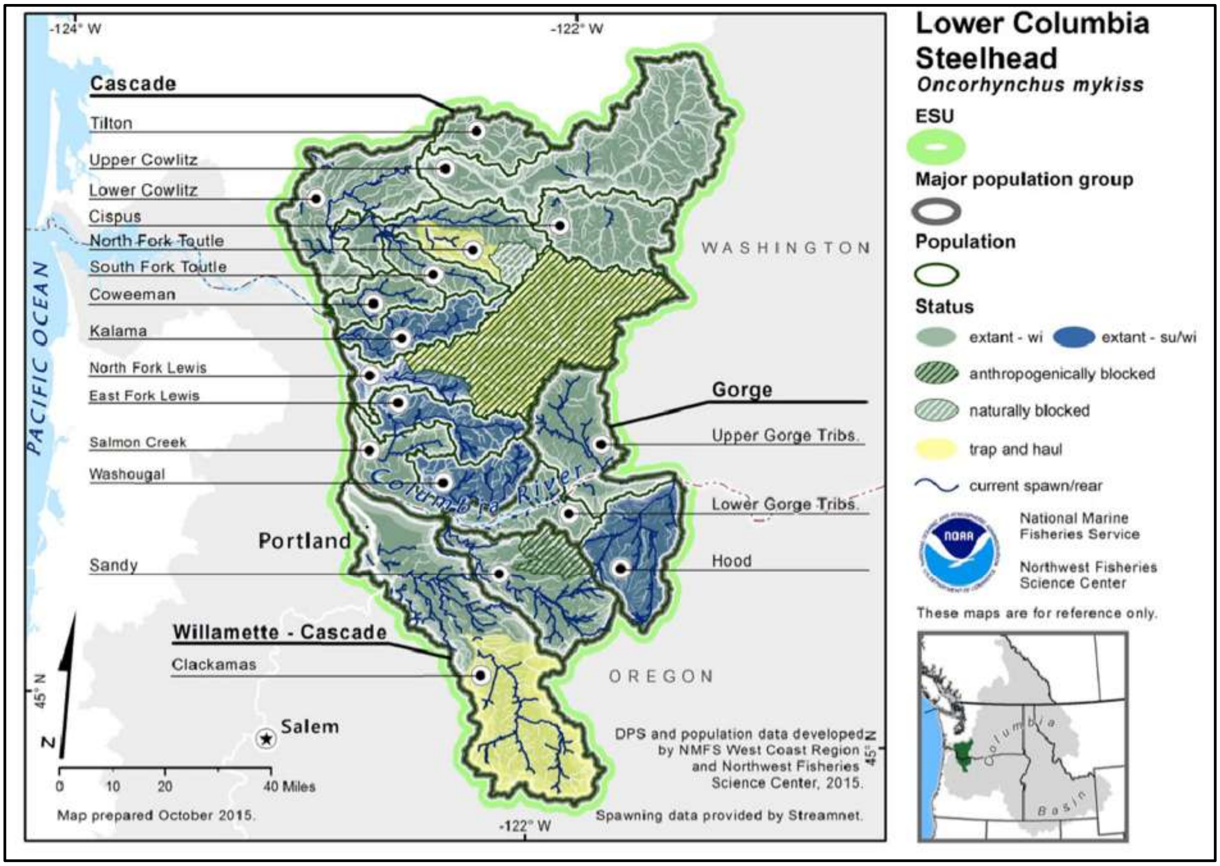

Figure 2.11-1. Map of the LCR steelhead DPS's spawning and rearing areas, illustrating populations and major population groups. Source: NWFSC 2015.

2.11.1.1.2 Life-History and Factors for Decline

Steelhead spawn in a wide range of conditions, from large streams and rivers to small streams and side channels. Returning adult summer-run steelhead can reach headwater areas above waterfalls that are impassable to winter steelhead during high-velocity winter flows. The two

Clackamas Hatchery Late Winter-run Program; Sandy Hatchery Late Winter-run Program; Hood River Winter-run Program; and Lewis River Wild Late-run Winter Steelhead Program. In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including LCR steelhead (81 FR 72759). The proposed changes for hatchery program inclusion in this DPS were to add the Upper Cowlitz River Wild Program and the Tilton River Wild Program. We expect to publish the final revisions in 2020. For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in a DPS, see NMFS (2005c).

[360] The W/LC TRT used the term "strata" to refer to these population groupings, which are significant in identifying delisting criteria. The strata are analogous to the "major population groups" defined by the ICTRT. For consistency, we use the term "major population group" throughout this opinion.

life-history types (summer- and winter-run) differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning (NMFS 2013b). Generally, summer-run steelhead enter freshwater from May to October in a sexually immature condition, and require several months in freshwater to reach sexual maturity and spawn between late February and early April. Winter-run steelhead enter freshwater from November to April in a sexually mature condition and spawn in late April and early May. Iteroparity (repeat spawning) rates for Columbia River basin steelhead have been reported as high as 2 to 6 percent for summer steelhead and 8 to 17 percent for winter steelhead (Leider et al. 1986, Busby et al. 1996, Hulett et al. 1996). The holding period for summer steelhead allows them to take advantage of periodically favorable passage conditions, but it may also result in higher pre-spawning mortality that puts summer-run steelhead at a competitive disadvantage relative to winter-run steelhead. Young steelhead typically rear in streams for 1 to 4 years before migrating to the ocean, with most migrating after 2 years in freshwater. In the lower Columbia River, outmigration of steelhead smolts (of both summer and winter life-history types) generally occurs from March to June, with peak migration usually in April or May (NMFS 2013b).

Declines in LCR steelhead have been caused by habitat degradation, harvest, hatchery production, and hydropower development that together have reduced the persistence probability of almost every population. Historically, high harvest rates contributed to population depletions, while stock transfers and straying of hatchery-origin fish reduced productivity and genetic and life-history diversity. Construction of tributary and mainstem dams has constrained the spatial structure of some steelhead populations by blocking or impairing access to historical spawning areas. Over time, population abundance and productivity have been reduced through habitat alterations. Habitat alterations in the Columbia River estuary have also contributed to increased predation on steelhead juveniles (NMFS 2013b).

2.11.1.1.3 Recovery Plan

The ESA recovery plan for LCR steelhead (NMFS 2013b) includes delisting criteria for the DPS, along with identification of factors currently limiting its recovery, and management actions necessary for recovery. The biological delisting criteria are based on recommendations by the W/LC TRT.[361] They are hierarchical in nature, with DPS-level criteria based on the status of natural-origin LCR steelhead assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the DPS will require sufficient improvement in its abundance, productivity, spatial structure, and diversity.

The DPS-level criterion is that each MPG that historically existed must have a high probability of persistence or have a probability of persistence consistent with its historical condition. The

[361] The recovery plan also includes "threats criteria" for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

recovery plan also contains criteria for determining whether an MPG has met that standard, based on the status of the individual populations in the MPG (NMFS 2013b). It also identifies specific population-level goals consistent with the MPG-level criteria (NMFS 2013b). The recovery strategy involves reducing threats in all categories, but crucial elements include: 1) protecting and restoring tributary habitat, especially in subbasins where large improvements in population abundance and productivity are needed to achieve recovery goals, 2) significantly reducing hatchery impacts, 3) reestablishing naturally spawning winter steelhead populations above tributary dams in the Cowlitz system (Upper Cowlitz and Cispus populations) and improving the status of the Tilton and North Fork Lewis winter steelhead populations, and 4) reducing predation.

2.11.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within the DPS based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the W/LC TRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low extinction risk. For LCR steelhead, recovery requires improving all four MPGs to a high probability of persistence or a probability of persistence consistent with their historical condition.

The most recent status review concluded that the majority of winter- and summer-run steelhead populations continued to persist at low abundances (NMFS 2016i). For winter-run populations, abundances had remained fairly stable but low (averaging in the hundreds of fish). Notable exceptions to this were the Clackamas and Sandy River winter-run populations, which showed increased natural-origin abundance and low levels of hatchery-origin spawners. For summer-run populations where abundance data were available, abundances had also been relatively stable but also low (averaging in the hundreds of fish). However, the most recent surveys available at the time (from 2014) indicated a drop in abundance, which was of concern and considered possibly a portent of changing ocean conditions (NWFSC 2015).

Historical and ongoing hatchery effects continue to affect genetic diversity and productivity in both summer- and winter-run populations, but the most recent status review found the overall situation somewhat improved compared to the previous review (NWFSC 2015, NMFS 2016i). Total steelhead hatchery releases in the DPS had decreased since the previous status review, in 2011, declining from a total (summer- and winter-run) release of approximately 3.5 million to 3 million from 2008 to 2014. Some populations continued to have relatively high fractions of hatchery-origin spawners, whereas others (e.g., Wind River) have relatively few (NWFSC 2015).

For populations in this DPS that had limitations on their spatial structure (or access to historical habitats), the most recent status review noted that there had been a number of large-scale efforts to improve access (NMFS 2016i). A sample of these includes efforts to provide access to the upper Cowlitz River basin (beginning in 1996) and structural and operational changes at the dam to improve juvenile collection efficiency; removal of Powerdale Dam, on the Hood River, 2010; trap and haul operations on the Lewis River beginning in 2012; removal of Condit Dam, on the White Salmon River, in 2012; trap and haul operations at the sediment retention structure on the North Fork Toutle River, underway since 1989; removal of Marmot and Little Sandy Dams on the Sandy River in 2008, and removal of Hemlock Dam on Trout Creek, in the Wind River, in 2009. The most recent status review noted that many of these actions had occurred too recently to be fully evaluated. The review noted that, generally, where passage had been restored it remained to be demonstrated whether both adult and juvenile passage survival was sufficient to provide some level of self-sufficiency to upstream population components (NMFS 2016i, NWFSC 2015).

Overall, NMFS concluded in the most recent status review that the LCR steelhead DPS remained at moderate risk of extinction (NWFSC 2015, NMFS 2016i). Of the 23 populations, 16 were considered to be at high or very high risk of extinction, six had a moderate overall risk of extinction, and one had a low risk of extinction. None of the populations were considered fully viable. All four strata in the DPS fell short of their recovery goals, and most populations required substantial improvements to reach their recovery goals (NWFSC 2015). Table 2.11-1 lists the MPGs and populations in this DPS and summarizes their abundance/productivity, spatial structure, diversity, and overall population risk status at the time of the most recent status review; it also summarizes their target risk status for delisting (NMFS 2013b, 2016i; NWFSC 2015).

Table 2.11-1. LCR steelhead population-level risk for abundance productivity (A/P), spatial structure, diversity, overall extinction risk as of the most recent status review (NWFSC 2015, NMFS 2016i), and recovery plan target status (NMFS 2013b). Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH). The populations that spawn upstream of Bonneville Dam are highlighted in gray.

MPG		Population	A/P Risk Rating	Spatial Structure Risk Rating	Diversity Risk Rating	Overall Extinction Risk Rating	Recovery Plan Target Status
Ecological Subregion	**Run Timing**						
Cascade Range	**Summer**	Kalama (WA)	L	VL	M	M	L
		North Fork Lewis River (WA)	VH	VH	VH	VH	VH
		East Fork Lewis River (WA)	VH	VL	M	VH	L
		Washougal River (WA)	M	VL	M	M	L
	Winter	Lower Cowlitz (WA)	H	M	M	H	M
		Upper Cowlitz (WA)	VH	M	M	VH	L
		Cispus (WA)	VH	M	M	VH	L
		Tilton River (WA)	VH	M	M	VH	H
		South Fork Toutle River (WA)	M	VL	L	M	VL
		North Fork Toutle River (WA)	VH	L	L	VH	L
		Coweeman River (WA)	H	VL	VL	H	L
		Kalama River (WA)	H	VL	L	H	VL

MPG		Population	A/P Risk Rating	Spatial Structure Risk Rating	Diversity Risk Rating	Overall Extinction Risk Rating	Recovery Plan Target Status
Ecological Subregion	**Run Timing**						
		North Fork Lewis River (WA)	VH	M	M	VH	M
		East Fork Lewis River (WA)	M	VL	M	M	L
		Salmon Creek (WA)	VH	L	M	VH	VH
		Clackamas (OR)	M	VL	M	M	M
		Sandy (OR)	H	M	M	H	VL
		Washougal (WA)	H	VL	M	H	M
Columbia Gorge	**Summer**	Wind (WA)	VL	VL	L	L	VL
		Hood River (OR)	VH	VL	H	VH	L
	Winter	Lower Gorge (WA, OR)	H	VL	M	H	L
		Upper Gorge (WA, OR)	H	M	M	H	H
		Hood (OR)	M	VL	M	M	L

2.11.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the LCR steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed.

Because steelhead are stream-type fish that typically rear in tributary reaches for a year or more, they depend heavily on tributary habitat conditions for their early survival (LCFRB 2010). Loss and degradation of tributary habitat is one of the main limiting factors for LCR steelhead. Impaired side channel and wetland conditions, along with degraded floodplain habitat, degraded riparian conditions, and loss of channel structure and form, have significant negative impacts on juvenile steelhead throughout the DPS. In most cases, these limiting factors have resulted from channelization, diking, wetland conversion, stream clearing, and gravel extraction, which have barred steelhead from historically productive habitats and simplified remaining habitats, weakening watershed processes that are essential to the maintenance of healthy ecosystems and reducing refugia and resting places (NMFS 2013b). As stream-type fish, steelhead spend less time in the Columbia River estuary than do ocean-type salmon such as fall Chinook, yet estuary habitat conditions nevertheless play a role in the survival of steelhead juveniles, particularly those displaying less dominant life-history strategies (NMFS 2013b).

Tributary habitat dams limit access to historical habitat for some winter steelhead populations, particularly the Upper Cowlitz, Cispus, North Fork Lewis, and Tilton populations, and the North Fork Lewis summer-run population. Four populations (Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run) in two MPGs in this DPS are subject to CRS impacts involving passage at Bonneville Dam.

There is no direct harvest of naturally produced LCR steelhead other than a catch and release fishery in the Wind River (NWFSC 2015). They are intercepted in mainstem fisheries targeting unlisted hatchery and naturally produced Chinook salmon and unlisted steelhead, but overall impacts are low and harvest is not considered a primary limiting factor (NMFS 2013b).

High proportions of hatchery-origin spawners in some populations, combined with past stock transfers, are believed to have reduced genetic diversity within and among LCR steelhead populations. Productivity likewise has declined as a result of the influence of hatchery-origin fish. These high proportions of hatchery fish spawning naturally, along with releases of out-of DPS hatchery fish, remain a concern. We expect this factor to be greatly reduced by reforms identified in the biological opinion evaluating Mitchell Act funding (NMFS 2017i)—for example, beginning in 2019, out-of-DPS releases of hatchery steelhead inside this DPS's geographic range were terminated.

LCR steelhead populations are affected by predation by birds in the Columbia River estuary. Steelhead spawning above Bonneville Dam also are subject to predation by non-salmonid fish (primarily pikeminnow above and below the dam, but also walleye and smallmouth bass in the reservoir). Winter steelhead spawning above Bonneville Dam are also subject to predation by marine mammals (primarily sea lions) at Bonneville Dam (NMFS 2013b).

2.11.1.1.6 Information on Status of the Species since the 2016 Status Review

We do not have updated dam counts for this species comparable to those discussed in prior sections for interior basin salmon and steelhead, because most LCR steelhead spawning takes place below Bonneville Dam. The best scientific and commercial data available are at the population level (Table 2.11-2). These indicate a mix of recent increases, decreases, and relatively static numbers of natural-origin and total spawners in 2014 to 2018 compared to the 2009 to 2013 period.[362] However, in all cases where available, abundance estimates for 2019 were lower than the most recent 5year geometric means indicating a common driver such as poor ocean conditions (see discussion below).

[362] The upcoming 2021 status review is expected to include population-level adult returns through 2019, and the 5-year periods used for calculating geomeans will shift forward (i.e., the last period will include 2015 to 2019). Because 2014 adult returns represented a peak at the DPS level for some populations, shifting 2014 to the preceding 5-year grouping is likely to increase the negative percent change.

Table 2.11-2. 5-year geometric mean of natural-origin spawner counts for LCR steelhead. Number in parenthesis is the 5-year geometric mean of total spawner counts. If there is only a value in parentheses, the total spawner count was the only available data for a population (i.e., there was no, or only one, estimate of natural spawners for the 5-year period). "% change" is a comparison between the two most recent 5-year periods (2014-2018 compared to 2009-2013). "NA" means not available. An "*" indicates two missing years of data from the dataset. At the time of drafting this opinion, 2019 data were available for most, but not all LCR steelhead populations. Source: Williams (2020c, e).

MPG	Population	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
Cascade	Kalama River - summer	(318)	(380)	(493)	(567)	(15)	(377)
	Kalama River - winter	(1072)	(1440)	(883)	(891)	(1)	(153)
	Sandy River - winter	NA	NA	997 (1103)	4026 (4263)	304 (286)	1896 (2032)
	Clackamas River - winter	NA	NA	(3525)	3322 (3066)	(-13)	1500 (1702)
	Coweeman River-winter	(354)	(488)	(460)	(565)	(23)	(354)
	East Fork Lewis River - winter	(401)	(514)	(394)	(644)	(63)	(322)
	East Fork Lewis River - summer	(322)	(475)	(894)	(721)	(-19)	(367)
	Upper Cowlitz River - winter	266 (802)	429 (1056)	523 (778)	130 (396)	-75 (-49)	NA
	North Fork Toutle River - winter	NA	NA	(338)	(501)	(48)	(112)
	South Fork Toutle River - winter	(621)	(622)	(402)	(792)	(97)	(284)
	Washougal River - winter	(343)	(613)	(333)	(531)	(59)	(130)
	Washougal River - summer	(243)	(668)	(660)*	(667)	(1)	(456)
	Tilton River - winter	190 (839)	160 (310)	231 (368)	251 (306)	9 (-17)	NA
Columbia Gorge	Upper Gorge Tributaries - winter	(35)	(17)	(21)	(9)	(-57)	(8)
	Hood River - winter	NA	NA	NA	501 (1080)	NA	NA

MPG	Population	1999-2003	2004-2008	2009-2013	2014-2018	% Change	2019
	Wind River - summer	483 (541)	703 (707)	845 (850)	617 (622)	-27 (-27)	(303)

NMFS will evaluate the implications for extinction risk of these more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.11-2.

Many LCR steelhead populations have increased in abundance since the 1990s, but even these appear to have been affected by recent poor ocean conditions. These conditions (e.g., temperature and salinity, coastal food webs), appeared to be more favorable to steelhead survival and adult returns in 2018, but were still impacted by recent warming trends.

2.11.1.2 Status of Critical Habitat

NMFS (2005a) designated critical habitat for LCR steelhead to include all estuarine areas and river reaches from the mouth of the Columbia River upstream to the confluence with the Hood River (50 CFR 226.212(q)). Critical habitat for LCR steelhead encompasses eight subbasins in Oregon and Washington containing 38 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2013b) and have some, or high, potential for improvement. Similar to the discussion above regarding effects on the species, the status of critical habitat is likely to be affected by climate change, with predicted rising temperatures and alterations in stream flow patterns. Improved access to spawning and rearing habitat, and habitat restoration efforts, will help reduce those effects on critical habitat.

Of the 38 designated HUC5[363] watersheds within the range of this DPS, NMFS (2005b) gave 29 a high rating, eight a medium rating, and one a low rating for their value to the conservation (i.e., recovery) of the species. The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

[363] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country. A HUC5 is a five-unit (5 two-digit numbers) code. Examples are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the Wenatchee Basin, Washington.

In evaluating the quantity and quality of habitat features, NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b), as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.
- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.
- Nearshore marine areas free of obstruction, with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation,

> large rocks and boulders, and side channels. As in the case of freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Critical habitat also has been designated for LCR steelhead in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. NMFS considers the estuary to have a high conservation value because it connects every population with the ocean and is used by rearing and migrating juveniles and by migrating adults.

Human activities since the late 1800s have altered the form and function of the Columbia River estuary, reducing the quantity and quality of its PBFs. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained this environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in the mainstem navigation channel; and causeways have been constructed that restrict the position of tributary confluences.

In addition, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban use. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from upstream reservoirs have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. In addition, Bottom et al. (2005) estimate that reduced river flows caused by hydrosystem operations and climate change together have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of established flow variations in the Columbia River estuary through flow regulation may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has eliminated shallow-water habitats, which were seasonally important rearing areas and refugia for juvenile salmonids. Disconnecting the tidal river from its floodplain also prevented delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The remainder of the area designated as critical habitat is in the reservoir reach between Bonneville Dam and the Hood River confluence. NMFS (2005b) designated critical habitat in six occupied HUC5 watersheds in the Middle Columbia/Hood subbasin and rated four as having high, one as having medium, and one as having low conservation value. The reservoir itself is part of the high value rearing and migration corridor connecting important upstream watersheds with downstream reaches and the ocean. Its conservation value has been affected by upstream and downstream passage at Bonneville Dam. Any historical spawning or rearing habitat in the lower reaches of the tributaries that had been used by LCR steelhead populations is now under the reservoir. In most designated tributary watersheds, stream habitat, water quality, and watershed processes have been degraded by development and other land use activities.

The effect of these changes as a whole is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs and thus the conservation value of critical habitat for LCR steelhead within the action area are discussed in more detail in the Environmental Baseline section, below.

2.11.1.3 Climate Change Implications for LCR Steelhead and Critical Habitat

One factor affecting the rangewide status of LCR steelhead and aquatic habitat is climate change. The USGCRP[364] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[365] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.

[364] http://www.globalchange.gov

[365] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

Likely changes in temperature, precipitation, and wind patterns (as well as sea-level rise in the lower estuary) have implications for survival and recovery of LCR steelhead in both their freshwater, estuarine, and marine habitats and the PBFs of their critical habitat. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009, Mote et al. 2014). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (ISAB 2007). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1 to 4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure, and coastal wetlands and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, certain management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations). Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends on both the characteristics of individual populations and the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable, so maintaining or promoting the diversity currently found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR steelhead DPS.

Climate change would affect LCR steelhead and critical habitat through physical and chemical changes to their habitats (e.g., increased water temperature, decreased ocean pH, changes in the timing and volume of stream flow). The physical and chemical changes may result in biological impacts such as, but not limited to, reduced ocean survival, changes in growth and development, and changes in run timing and spawning timing (Link et al. 2015). These biological changes can lead to changes in species productivity and abundance, distribution, food web structure, community structure, invasive species impacts, and biodiversity and resilience (Link et al. 2015).

Crozier et al. (2019) assessed LCR steelhead as having moderate vulnerability to the effects of climate change based on an analysis of the DPS's sensitivity (moderate) and exposure (high).

Further, this DPS was determined to have high adaptive capacity (Crozier et al. 2019).[366] Overall, the moderate ranking for this DPS reflected substantial exposure to changes in the freshwater environment tempered by moderate sensitivity via tolerance for warm conditions and reproductive timing that avoids peak temperatures. Exposure to ocean acidification was very high due to the strong magnitude of expected pH change, the broad spatial extent of ocean acidification, and the certainty in the direction of change. Exposure was also ranked high for sea surface temperature, reflecting the broad spatial extent of this attribute. Exposure to stream temperature was ranked very high, and exposure to summer water deficit was moderate.

Exposure to nearshore attributes was low, since these steelhead tend to spend less time in the nearshore environment and migrate offshore more quickly than some other salmon species. These nearshore attributes to which steelhead had low exposure included sea level rise, upwelling, and ocean currents.

Wade et al. (2013) found that relative to other Pacific Northwest steelhead, LCR steelhead had moderate exposure to expected changes in stream temperature and high exposure to changes in flow. Steelhead of this DPS were expected to have high sensitivity scores based on habitat condition and threatened population status.

LCR steelhead juveniles migrate rapidly through the estuary in late spring and experience a short window of exposure to estuarine factors relative to other species (Fresh et al. 2005). Therefore, exposure to sea level rise effects on the estuary was low. Compared to other steelhead, however, fish in this DPS use the estuary more extensively, and therefore these fish had slightly higher exposure scores for sea level rise than other Oregon and Washington steelhead stocks.

LCR steelhead can tolerate a broad range of temperatures and have a very flexible life-history. However, this DPS may have to shift migration or spawn timing if hydrologic regime changes affect migration and spawning (Wade et al. 2013). Overall, the adaptive capacity score for this DPS was high.

2.11.2 Environmental Baseline

The “environmental baseline” refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation; and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or

[366] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results.

designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For LCR steelhead, we focus our description of the environmental baseline on the portion of the action area where LCR steelhead juveniles and adults are most exposed to the effects of the proposed action. We also include tributary habitat because these habitats, while not influenced by the proposed action, are primary drivers for the elements of VSP for LCR steelhead, and thus are key habitats for recovery of the DPS, and are important to understand in the context of the proposed action.

To determine the upstream extent of LCR steelhead distribution and thus exposure to effects of the proposed action, we reviewed LCR steelhead PIT detections at Bonneville, The Dalles, and McNary Dams from 2013 through 2019.[367] PIT detections are an indication of presence/absence and not absolute abundance, because the proportion of the population that is tagged varies from year to year and is not known. The 7-year average of LCR steelhead detections is 274 adults at Bonneville Dam, nine adults at The Dalles Dam, and one at McNary Dam (DART 2020b), meaning that only about 3 percent of the fish passing Bonneville Dam also passed The Dalles Dam, and only 0.2 percent passed McNary Dam. Based on this information, small numbers of adults enter The Dalles Reservoir, and very few likely enter John Day or McNary Reservoirs. Therefore, the area where LCR steelhead experience the effects of the proposed action is the Columbia River from the tailrace of John Day Dam to the plume,[368] including tributary confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions.

2.11.2.1 Mainstem Habitat

On the mainstem of the Columbia River, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998,

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[367] A PIT tag detector has only been operational in the north fishway at John Day Dam since 2018. There is no PIT tag detector in the south fishway.

[368] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.11-2). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

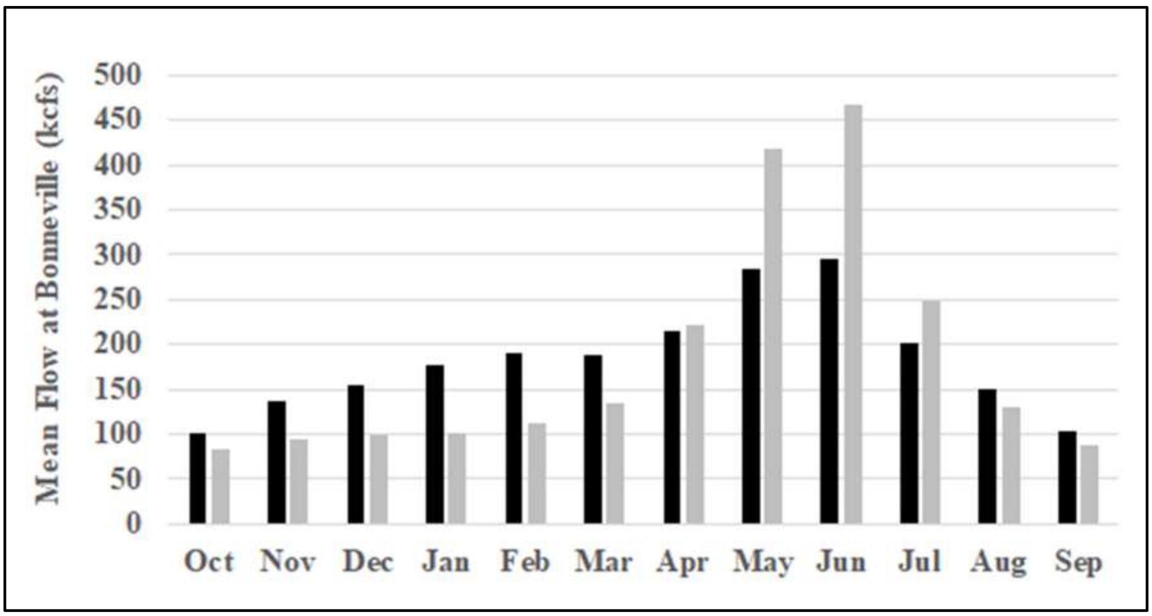

Figure 2.11-2. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[369] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and

[369] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile salmonids and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.11.2.2 Passage Survival

Only four of the 23 populations in this DPS are affected by passage conditions at Bonneville Dam: the Wind summer steelhead, Hood summer steelhead, Hood winter steelhead, and Upper Gorge winter steelhead populations. Based on PIT detections, small numbers of adult LCR steelhead (about eight per year) also migrate upstream of The Dalles Dam. Some of these fish could spawn in tributaries above The Dalles Dam, but there are no data to support this hypothesis. It is likely that most fall back, through either the turbines or the sluiceway (a safer route), and find their home tributaries. The survival of juvenile downstream migrants, including LCR steelhead, has improved over the last two decades with the installation of minimum gap turbine blade runners at Bonneville Powerhouse 1, fish guidance efficiency improvements at Powerhouse 2, the surface collector bypass system at Powerhouse 2, improvements to sluiceway fish guidance system (efficiency and conveyance) at Powerhouse 1, and increases in the percentage of flow approaching the dam that goes over the spillway.[370] All of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). Average survival for juvenile steelhead at Bonneville Dam was estimated to be 97 percent based on juvenile survival studies conducted in 2010 and 2011 (BPA et al. 2020) that looked at survival through the spillway, Powerhouse 2 (juvenile bypass system, turbines, and corner collector), and Powerhouse 1 (turbines and sluiceway). Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

The effects of tributary dams vary among steelhead populations. In the Cascade Winter steelhead MPG, tributary hydropower development is a primary limiting factor for adults and juveniles in the Upper Cowlitz, Cispus, and North Fork Lewis populations, which historically were among the most productive winter steelhead populations. For the Tilton population, access to significant amounts of historical habitat in these river systems has been blocked by tributary dams, which also have had adverse impacts on downstream habitat through reduced gravel recruitment and other effects. Tributary hydropower issues related to upstream passage of adult winter steelhead past the Bull Run water system dams in the Sandy subbasin, and downstream passage of juvenile winter steelhead through the Portland General Electric Clackamas River Project, were identified as secondary limiting factors. There are no tributary hydropower facilities in the Coweeman, Toutle, Kalama, Salmon Creek, or Washougal subbasins.

In the Cascade summer steelhead MPG, impaired habitat access and passage has been identified as a primary limiting factor for North Fork Lewis summer steelhead; tributary dams have blocked access to or inundated about 50 percent of the historical habitat for that population (LCFRB 2010). In addition, tributary dams have adverse effects on downstream habitat through reduced gravel recruitment and other impacts. There are no tributary hydropower facilities in the Kalama and Washougal subbasins.

In the Gorge Winter steelhead MPG, impaired adult passage is considered a secondary limiting factor for the Hood River population because of Laurence Lake Dam and Powerdale Dam (removed in 2010). The impacts of Bonneville Dam on adult and juvenile passage are identified as a secondary factor for both the Upper Gorge Winter and Hood Winter steelhead populations.

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[370] At Bonneville Dam, juvenile steelhead survival rates through the various passage routes under tested operational conditions are generally: turbines < spillway < PH1 surface passage route (sluiceway) < PH2 juvenile bypass system and surface passage route (corner collector). Increasing spill would be expected to increase survival rates to the extent fish are moved from turbine units to this route of passage, but would tend to decrease survival rates to the extent fish are moved from surface passage routes or the juvenile bypass system.

Upstream passage to potential spawning grounds is limited by Bonneville Dam, and inundation of historical habitat has reduced habitat quantity for juveniles.

In the Gorge Summer steelhead MPG, Powerdale Dam on the Hood River hindered access of adult steelhead to historical spawning areas until its removal in 2010 (NMFS 2013b). Inundation from the Bonneville Dam and the concomitant loss of historical riparian ecosystems has also reduced habitat quality for juvenile summer steelhead in the Hood River population.

Information on CRS-related mortality of downstream migrating kelts is limited, but kelt survival research conducted in 2012 and 2013 can be useful in understanding the survival of kelts from LCR steelhead populations originating above Bonneville Dam. Colotelo et al. (2014) estimated that 66.7 percent of Snake River Steelhead kelts survived from the confluence of the Snake River near Burbank Washington to the Bonneville Dam forebay and survival per kilometer was estimated at 99.86 through this reach. These researchers also estimated that 91.0 percent of kelts tagged in the Snake River survived from the Bonneville forebay to the Kalama River (RM 78.3). Using LCR steelhead and SRB steelhead, Rayamajhi et al. (2013) estimated that kelt survival through The Dalles Dam was 88.3 percent and survival through Bonneville Dam was 86.7 percent. Both studies found strong evidence that survival through spillway and surface passage routes were higher than survival of fish passing through turbines. It is an important consideration that these studies were conducted after the juvenile passage season had begun, and survival is likely lower for kelts attempting to pass before spillway and surface passage protections are provided. Based on this limited information, up to 40 percent of kelts arriving at McNary Dam are lost upstream of Bonneville Dam. Far lower proportions of kelts entering Bonneville Reservoir would be expected to be lost. Assuming roughly equal losses between the three projects in this reach, about 10 to 15 percent of LCR steelhead kelts from populations upstream of Bonneville Dam might be lost before passing the dam. These data represent total mortality to outmigrating SR steelhead kelts, which we use as a reasonable surrogate for mortality of LCR steelhead kelts without sufficient data. These estimates do not distinguish between mortality caused by effects of CRS operations and other factors. Estimates of “natural” mortality rates for these fish are not available, but are thought to be high, as they have typically gone many months without feeding while expending considerable energy migrating and spawning.

2.11.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river’s major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult LCR steelhead is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of LCR steelhead, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead survival is a concern; because of temperature standard exceedances, portions of the lower Columbia River are on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.

- Point-source discharges such as cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat. In past years, state regulatory agencies have issued waivers for TDG as measured in the forebay and tailrace to allow increased spill as a way to facilitate the downstream movement of juvenile salmonids (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death

(Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at the base of the spillway at each Federal mainstem run-of-river dam, except The Dalles Dam. Biological monitoring shows that the incidence of observable GBT symptoms is between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).[371] Under recent operations (2008 to 2019), elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June. Monitoring data from 1998 to 2018 indicate that TDG did not increase instantaneous mortality rates for juvenile steelhead in the CRS (CSS 2019).

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

2.11.2.3.1 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam),

[371] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of LCR steelhead in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[372] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[373] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic

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[372] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[373] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river

activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.11.2.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements at Ice Harbor Dam) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adult LCR steelhead that are migrating past the dams or overwintering within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Few to no juvenile steelhead have been affected by these activities, because they predominantly migrate from April to June.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult LCR steelhead has likely resulted in passage delay, handling, and some mortality during some outages, but measures to reduce these impacts such as providing attraction flow and alternative ladders and passage routes have minimized the impacts.

2.11.2.5 Tributary Habitat

Tributary habitat conditions for the LCR steelhead DPS have in general been significantly degraded by an array of land uses, including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions (contributing to stream channel simplification, reduced bank stability, increased sediment load, and elevated water temperatures) (NMFS 2013b, 2016i). In addition, tributary dams have blocked or impeded passage and access to historical habitat for LCR steelhead populations in the Cowlitz, Lewis, Clackamas, Sandy, and Hood subbasins, although these dams are no longer a factor in the Hood and Sandy subbasins since removal of Powerdale Dam (on the Hood River, in 2010) and Marmot and Little Sandy Dams (on the Sandy River, in 2008). Four LCR steelhead populations historically spawned above Bonneville Dam, so adults and juveniles in these populations must pass Bonneville Dam; in addition, the reservoir created when the dam was completed in 1938 may have reduced habitat quality for juveniles in these populations (NMFS 2013b).

Numerous tributary habitat protection and restoration actions have been implemented in recent years by local recovery planning groups, Federal and state agencies, tribal governments, local governments, conservation groups, private landowners, and other entities. These efforts have led to some local improvements in tributary habitat conditions (NMFS 2016i). However, degraded habitat conditions throughout the range of LCR steelhead, particularly with regard to channel complexity, side channel and floodplain connectivity, water-quality and hydrologic patterns, and toxic contamination from exposure to emerging and legacy chemicals, continue to negatively affect the abundance, productivity, spatial structure, and diversity of LCR steelhead populations (NMFS 2016i). Continued land development and habitat degradation, in combination with the potential effects of climate change, may present a continuing strong negative influence (NWFSC 2015).

2.11.2.6 Estuary Habitat

The Columbia River estuary provides important migration habitat for LCR steelhead. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the estuary have been lost to diking, filling, and bank hardening combined with hydrosystem flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus that supports salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review, have improved access and connectivity to floodplain habitat (NMFS 2016i). From 2007 through 2019, restoration sponsors implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents a more than a 2.5 percent net increase in a connectivity index for these wetland habitats (Johnson et al. 2018). Although yearling steelhead migrants are less likely to enter and rear in these areas, the large amounts of prey (particularly chironomid insects) exported from restored wetlands to the mainstem are actively consumed by these fish, especially natural-origin smolts. The resulting growth likely contributes to survival at ocean entry (PNNL and NMFS 2020). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

As discussed in Section 2.11.2.3 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, the levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, and they are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.11.2.7 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect natural populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Historical hatchery effects and ongoing hatchery straying have reduced genetic diversity and productivity in both summer and winter LCR steelhead populations (NMFS 2013b). NMFS directs Federal funding to many of the hatchery programs that affect the LCR steelhead DPS through the Mitchell Act. In 2017, NMFS completed an EIS and new biological opinion on its funding of the Mitchell Act program (NMFS 2017i). The Mitchell Act Record of Decision directs NMFS to apply strong performance goals to reduce the risks of hatchery programs on natural-origin populations. As a result, several additional hatchery reform measures have been or will be implemented, as described below. The implementation of these reform measures is expected to improve the status of the DPS:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could potentially be affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs, along with the installation of six new seasonal weirs because, in some tributaries, there

have been too many hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk. The production-level changes will reduce the pHOS[374] (Table 2.11-3) and reduce genetic and ecological risk.

- Elimination of the release of Chambers Creek steelhead, a hatchery stock that does not originate from within the Columbia River basin. This change will reduce genetic risk to the ESA-listed LCR steelhead DPS.
- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards, ensuring that they minimize adverse impacts to ESA-listed fish.

Even with these improvements, hatchery production will continue to limit the diversity and productivity of natural-origin LCR steelhead. In addition, LCR steelhead are affected by hatchery production of salmon and steelhead from other ESUs and DPSs. Hatchery programs were designed to conserve vital genetic resources and to supplement harvest levels to compensate for losses throughout their life cycle. Some scientists suspect that closely spaced releases of hatchery fish from all Columbia River basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2006) and the Lower Columbia Fish Recovery Board (LCFRB 2010) identified competition for food and space among hatchery-origin and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged this uncertainty, but listed competition for food and space as a secondary limiting factor for juveniles of all populations.

Table 2.11-3. Expected genetic effect levels on LCR steelhead populations potentially affected by Mitchell Act-funded hatchery programs.

Major Population Group	Population	Recovery Designation	Expected Maximum Gene Flow from MA Programs Once Fully Implemented	Expected Census pHOS Levels from MA Programs Once Fully Implemented
Cascade (winter)	**Coweeman**	Primary	≤2.0%	≤5.0%
	SF Toutle	Primary	≤2.0%	≤5.0%
	Kalama	Primary	≤2.0%	≤5.0%
	Salmon Cr	Stabilizing	≤2.0%	≤5.0%
	Clackamas	Primary	NA	Winter program: ≤10.0% Summer program: ≤5.0%
	Washougal	Contributing	≤2.0%	≤5.0%
	Sandy	Primary	NA	Winter program: ≤10.0% Summer program: ≤5.0%
Cascade (summer)	**Kalama**	Primary	≤2.0%	≤5.0%
	Washougal	Primary	≤2.0%	≤5.0%

374 Percent hatchery fish on the spawning grounds.

Major Population Group	Population	Recovery Designation	Expected Maximum Gene Flow from MA Programs Once Fully Implemented	Expected Census pHOS Levels from MA Programs Once Fully Implemented
Gorge (winter)	**Upper Gorge**	Stabilizing	≤2.0%	≤5.0%

2.11.2.8 Recent Ocean and Lower River Harvest

In February 2018, NMFS signed the 2018 to 2027 *U.S. v. Oregon* Management Agreement of the Columbia River Basin, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. The decision was based on both our recently completed Final EIS and the associated biological opinion (NMFS 2018a). This agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho; ensures fair sharing of harvestable fish between tribal and nontribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*; protects and conserves ESA-listed and unlisted species; and ensures that NMFS fulfills its trust/treaty responsibilities to Columbia River basin tribes. Other than a catch-and-release fishery in the Wind River, no directed fisheries for naturally produced LCR steelhead occur in the Columbia River basin.

Steelhead are intercepted in mainstem fisheries targeting hatchery and unlisted naturally produced Chinook salmon, and unlisted steelhead. Mark-selective net fisheries in the mainstem Columbia River can result in post-release mortality rates of 10 to over 30 percent, although there is considerable disagreement on the overall rate (NMFS 2016i). Recreational fisheries targeting marked hatchery-origin steelhead encounter natural-origin fish at a relatively high rate, but hooking mortalities are generally lower than those in the net fisheries. Estimated mortality for naturally produced winter-run steelhead has averaged 2.2 percent (2009 to 2013) for nontribal commercial and recreational fisheries (ODFW and WDFW 2015). The current *U.S. v. Oregon* Management Agreement has, on average, maintained reduced harvest impact for LCR steelhead fisheries, with 2014 harvest rates for winter-run steelhead in mainstem fisheries at 0.6 percent and with harvest rates for summer-run steelhead below 15 percent for those above Bonneville Dam (NWFSC 2015).

2.11.2.9 Predation

2.11.2.9.1 Avian Predation

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including LCR steelhead) in the Columbia River.

Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where marine forage fish were available to diversify the tern diet. Roby et al. (2017) estimated that terns on East Sand Island consumed an average of 5.1 million smolts per year, a 59 percent reduction from when the colony was on Rice Island.

Evans and Payton (2020) estimated Caspian tern predation rates for LCR steelhead using a model that adjusts for tag deposition rates[375] as described above for Interior Columbia ESUs/DPSs. Average annual tern predation rates were reduced from 15.2 to 10.4 percent during the pre-management and management periods, respectively, a statistically credible difference (Evans and Payton 2020) (Appendix B). This improvement in Caspian tern predation rates was offset to an unknown degree by about 1,000 terns roosting or trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on LCR steelhead in 2003 to 2014 was 5.4 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[376] where smolts are likely to constitute a larger proportion of the cormorants' diet. The average annual predation rates on LCR steelhead reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (5.0 percent in 2015 to 2017 and 0.6 percent in 2018, respectively)[377] therefore cannot be directly compared to those before management began, and are likely to underestimate predation rates in the estuary.

In the hydrosystem reach, the Action Agencies have employed wire arrays, pyrotechnics, water cannons, and other measures, including limited lethal take at project tailraces in the lower Columbia River. These measures have been shown to reduce predation rates on juvenile

[375] Deposition rate is the probability that once a bird eats a PIT-tagged fish, the tag (which passes through the digestive system) will be excreted at the colony versus over the water or some other land feature.

[376] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge; Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

[377] Management actions for the double-crested cormorant colony on East Sand Island included lethal take of eggs and adults and passive dissuasion during Phase I (2015 to 2017) and lethal take of eggs (only) and passive dissuasion during Phase II (2018).

salmonids at John Day and The Dalles Dams, and may have had similar effects at Bonneville Dam (Zorich et al. 2012).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on LCR steelhead after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts over estimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead; and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different but related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., had no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns (an additive effect). But the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, will also be important.[378]

With respect to managing terns in the estuary, Caspian terns nesting on East Sand Island were eating an average of 15.2 percent of the juvenile LCR steelhead outmigrants per year before

[378] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

management actions reduced the size of that colony, and 10.4 percent per year thereafter (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (15.2 percent) and the average 4.8 percent per year decrease achieved by reducing the size of the tern colony, this particular management measure may not have increased adult returns for LCR steelhead if ocean conditions overwhelmed improvements in freshwater survival. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 5.4 percent to less than 1 percent. However, in this case, smolt predation rates on LCR steelhead are likely to have increased because thousands of birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[379]

2.11.2.9.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). From 2015 to 2019, an annual average of 44 adults, and 165 juvenile steelhead were incidentally caught in the Sport Reward Fishery (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Although it was not practical for the field crews to identify these fish to DPS, a proportion of these fish could be LCR steelhead.

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019. These anglers did not catch any steelhead from 2015 through 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). During these same years, the Dam Angling Program has removed an average of 2,792 northern pikeminnow from The Dalles Dam tailrace

[379] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

alone, but since the LCR steelhead DPS only includes populations found below The Dalles Dam, this program is not likely to provide much benefit to juvenile LCR steelhead.

Juvenile salmonids are also consumed by nonnative fishes, including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these fish in the lower Columbia River and Bonneville Reservoir may incrementally improve juvenile steelhead survival.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile steelhead, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. In 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP. These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal remains unclear. However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the steelhead that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity for LCR steelhead. As such, it likely continues to benefit the DPS.

2.11.2.9.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions, Steller sea lions, and harbor seals all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace Bonneville Dam. ODFW counted the number of individual California sea lions hauling out in the Columbia River mouth at the East Mooring Basin in Astoria, Oregon, from 1997 to 2017. Individual pinniped counts at East Mooring Basin have steadily increased since the inception of the observation program with rapid increases within the last decade (Wright 2018). Within the Columbia River, the abundance of pinnipeds peaks in the spring but has also increased considerably when LCR steelhead adults are migrating through the estuary in the summer and early fall.

California sea lions and Steller sea lions prey on adult steelhead below Bonneville Dam and throughout the lower Columbia River. The population size of California sea lions has shown a steady increase from lows in the mid-1970s to levels above maximum net productivity level in 2014 (Lakke et al. 2018). Recent declines in pup production and survival suggest the population may have stopped growing. In the spring, consumption of steelhead from all DPSs at Bonneville Dam by California sea lions and Steller sea lions has ranged from a low of 2.2 percent in 2014 to a high of 11.0 percent in 2009 and 7.2 percent in 2018 (Tidwell et al. 2018). The percentage of steelhead consumed during the fall and winter was estimated to be 1.5 percent in 2017 (Tidwell et al. 2019), and 1.6 percent of steelhead were estimated to be consumed in 2018 (Tidwell et al. 2020).

Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 to 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019 respectively (Tidwell et al. 2018; Tidwell et al. 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between RM 112 and McNary Dam (RM 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

2.11.2.10 Research, Monitoring, and Evaluation Activities

The primary effects of the past and present CRS-related RME programs on LCR steelhead are those associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were LCR steelhead. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the LCR steelhead DPS by reducing predation throughout the migration corridor.

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For all other CRS-related RME programs, we estimated the number of LCR steelhead that have been handled (or have died) each year during the implementation of RME as the average annual take reported for 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of LCR steelhead associated with the associated with the Smolt Monitoring Program and the CSS were as follows:
    - No hatchery or natural-origin adults were handled.
    - No hatchery or natural-origin adults died.
    - Zero hatchery and 72 natural-origin juveniles were handled.
    - No hatchery or natural-origin juveniles died.

- Average annual estimates for LCR steelhead handling and mortality for all other RME programs were as follows:
  - One hatchery and zero natural-origin adults were handled.
  - No hatchery or natural-origin adults died.
  - 16 hatchery and 709 natural-origin juveniles were handled.
  - Zero hatchery and one natural-origin juvenile died.

The combined take (i.e.; handling, injury, and incidental mortality) of LCR steelhead associated with these elements of the RME program has, on average, affected zero percent of the natural-origin adult (recent, 5-year average) run (arriving at mouth of the Columbia River) and 0.22 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities, and therefore negatively affects LCR steelhead.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the DPS level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.11.2.11 Critical Habitat

The condition of LCR steelhead critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized here in Table 2.11-4. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for LCR steelhead production have been weakened. Conditions in the portion of the hydrosystem designated as critical habitat (i.e., the mainstem Columbia River below the confluence of the Hood River) were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for LCR steelhead have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.11-4. Physical and biological features (PBFs) of designated critical habitat for LCR steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development.	Tributary barriers (culverts, dams, water withdrawals), have reduced access to freshwater spawning sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations), has reduced the quality of freshwater spawning sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater spawning sites for all populations. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning sites for all populations. Some improvement in riparian, channel, and floodplain conditions in the lower ends of tributaries where large dams have been removed (e.g., White Salmon, Hood, and Sandy Rivers) has improved the quality of freshwater spawning sites for some populations. Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices), has reduced water quality in spawning sites for all populations. Inundation of the lower reaches of tributaries to Bonneville Reservoir has limited the availability of spawning sites for four of 23 populations (hydrosystem development). We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is available within the 5-foot operating range. Many tributary habitat improvement actions implemented in the lower Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to improve habitat complexity and riparian area condition, reduce fish entrainment, and remove barriers to spawning habitat.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, and natural cover.	Tributary barriers (culverts, dams, water withdrawals), have reduced access to freshwater rearing sites for many populations Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations. Excessive sediment in streambeds (unimproved roads, forest and agricultural practices) has reduced the quality of freshwater rearing sites for all populations. Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) have reduced water quality in freshwater rearing areas for many populations. The Corps has developed best management practices to avoid accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use "environmentally acceptable lubricants" where feasible. Inundation of the lower reaches of tributaries to Bonneville Reservoir has limited the availability of freshwater rearing habitat for four of 23 populations (hydrosystem development). We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is likely to be available within the 5-foot operating range.
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover.	Alteration of the seasonal flow regime in the lower Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation).[1] Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderate negative effect in lower flow years for all populations. Alteration of the seasonal mainstem temperature regime in the lower Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in the late summer and fall (hydrosystem development and operation).[1] In general, cooler spring temperatures do not adversely affect the functioning of the mainstem as a migration corridor for juveniles or for adults from summer-run populations. Adults from winter-run LCR steelhead populations enter the Columbia River beginning in November, after temperatures have cooled. Reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (hydrosystem development) may have reduced “natural cover” in the migration corridor for all populations. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining) affects all populations. The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use “environmentally acceptable lubricants” where feasible. Increased exposure of juveniles to TDG (water quality) in the gorge area and at least 35 miles below Bonneville Dam during involuntary and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor for juveniles and adults from populations in the Columbia Gorge MPGs. The incidence of adverse effects (GBT in juveniles and adults) appears to have been small in recent years (1 to 2 percent). Delay and mortality of juveniles and adults from Gorge populations at Bonneville Dam (hydrosystem development and operations) has increased obstructions in the migration corridor for four of 23 populations. However, obstructions have been substantially reduced for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult steelhead during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past Bonneville Dam). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile steelhead because few are present during the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include repair of the spillway apron at Bonneville Dam and overhauling the juvenile bypass system.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for predators, especially birds and pinnipeds in the tailrace of Bonneville Dam (excessive predation) for Gorge populations. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, and propane cannons. Pinniped predation is addressed by the use of sea lion excluder devices at the fishway entrances at Bonneville Dam.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity and salinity, natural cover, and juvenile and adult forage.	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production and the quantity and quality of estuarine rearing areas for all populations. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling steelhead by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation for all populations. Implementation of the Caspian Tern Management Plan on East Sand Island is reducing excessive predation on juvenile Chinook salmon, but depending on ocean conditions and compensatory effects, may not be increasing adult returns for LCR steelhead. Implementation of the Double-crested Cormorant Management Plan may have contributed to or coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rate for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island. Observations of increased pinniped predation and risk for adults from all populations.
Nearshore marine areas[2]	Free of obstruction and excessive predation with water quality, quantity, and forage.	Concerns about increased pinniped predation and adequate forage. Reduced quality of nearshore marine areas.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, High air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.11.2.12 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of LCR steelhead, including recent biological opinions issued for the LCR steelhead and key emergent or ongoing habitat concerns (NMFS 2016i). From January 2015 through May 22, 2020, we completed 486 formal consultations that addressed effects to LCR steelhead.[380] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPAs were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

[380] PCTS data query, July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.11.2.13 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of LCR steelhead populations. Recent improvements in passage conditions at Bonneville Dam and at tributary barriers, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. NMFS (2016i) identified past land development, habitat degradation, and predation, in combination with the potential effects of climate change, as limiting factors that continue to negatively affect LCR steelhead populations.

Likewise**,** the environmental baseline does not fully support the conservation value of designated critical habitat for LCR steelhead. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in the last two decades to improve the functioning of some of the PBFs of critical habitat. For example, surface passage structures and spill operations have reduced obstructions for juvenile LCR steelhead at Bonneville Dam. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. However, the factors described above continue to have negative effects on these PBFs.

2.11.3 Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species

(e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.11.3.1 Effects to Species

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams in an attempt to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns.[381] Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG ("gas cap spill") for a minimum of 16 hours per day, and may operate under "performance standard spill" for up to 8 hours per day. John Day Dam will spill up to 120 percent TDG for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs spill constraint) and 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in these periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under the higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.11-5.

Table 2.11-5. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[381] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.11-6. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.11-6. Proposed summer spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[2]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by

CRS operations (generally increased flows from October through March; decreased flows from May through August, and little change in flows in April and September) described in the environmental baseline will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse Dam operations are intended to benefit resident species. The change in Libby Dam operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce winter spill events (and associated elevated TDG levels), which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries when TDG is excessive. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.11-3).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

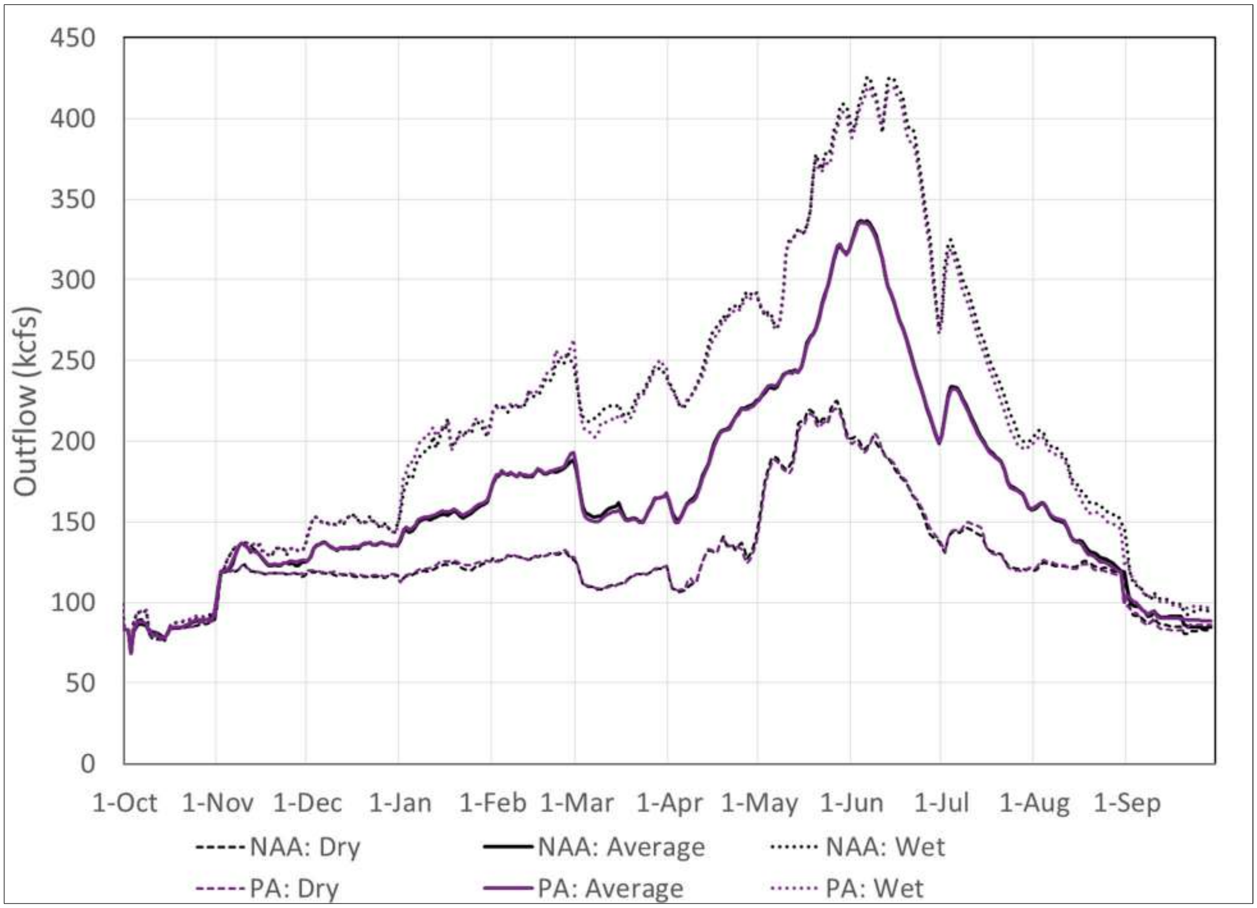

Figure 2.11-3. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

These proposed changes in reservoir operations are not likely to meaningfully affect the probability of meeting spring or summer flow objectives, and associated effects on LCR steelhead smolts or adults by a meaningful amount.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[382] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on LCR steelhead are likely to be very small and are not expected to detectably affect reach survival estimates.

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency hypothetically increases the exposure of LCR steelhead juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

[382] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

Juvenile LCR steelhead spend only days to weeks in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

The effects of the proposed hydrosystem operations and the non-operational measures on LCR steelhead and its habitat are described below.

2.11.3.1.1 Hydrosystem Operation

For LCR steelhead, the effects of operating the hydrosystem as proposed will generally be consistent with recent operations and mitigation measures (i.e., inundation of habitat, reduced velocities through the reservoir, altered food web, etc.) with the addition of the proposed flexible spill operation. Direct mainstem hydropower system impacts on LCR steelhead are most significant for the four populations that spawn in the Columbia River gorge upstream of Bonneville Dam, all of which are in the Gorge Winter (Upper Gorge and Hood) and Gorge Summer (Wind and Hood) MPGs. These populations are affected by upstream and downstream passage at Bonneville Dam and by the inundation of historical habitat, which has been used by juveniles in the past (McElhany et al. 2004). Impacts on populations originating in subbasins below Bonneville Dam are limited to effects on migration and habitat conditions in the LCR (below Bonneville Dam), including the estuary, because of changes in the hydrograph and movement of sediment.

Recent passage improvements[383] increased the survival of juvenile steelhead that pass through Bonneville Dam (Upper Gorge winter steelhead, Wind summer steelhead, Hood winter steelhead, and Hood summer steelhead populations). Reach survival for juvenile steelhead from The Dalles Dam to Bonneville Dam averages 89.1 percent. In 2018 and 2019, survival for juvenile steelhead through this reach was estimated at 97.4 and 85.7 percent, respectively (Zabel 2019, Widener et al. 2020). Since some LCR steelhead tributaries enter the Columbia River between Bonneville and The Dalles Dam, juveniles migrating from these tributaries will only migrate through a portion of this reach, and will be exposed to fewer predators, so their survival is likely to be higher than the estimated average reach survival. Based on 2010 and 2011 steelhead passage and survival studies, we estimate that 96.5 percent of juvenile steelhead that migrate past Bonneville Dam will survive through the dam and tailrace (Fredricks 2017).

For adults, the direct survival rate of steelhead at Bonneville Dam is quite high. Based on PIT-tag detections at Bonneville and The Dalles Dams, the upstream passage survival rate of adult LCR steelhead is 98.1percent (adjusted for harvest and straying).

[383] These include the installation of minimum gap runners at Bonneville PH1 and the fish guidance efficiency improvements at PH2, and improvements to the sluiceway fish guidance system (efficiency and conveyance) at PH1.

The survival rate for steelhead kelts passing through The Dalles Dam and Bonneville Dam was studied in spring 2012 (Rayamajhi et al. 2013). Survival for adult steelhead at The Dalles Dam ranged from 70 to 75 percent, depending on passage route. Survival at Bonneville Dam ranged from 50 to 100 percent, depending on passage route.

During periods of increased spill (spring), the effects to LCR steelhead include: 1) potential for increased fallback of adults for the two summer-run populations that spawn upstream of Bonneville Dam (Wind and Hood) that move upstream between April 15 and June 15, 2) increased likelihood that juveniles from all populations that spawn upstream of Bonneville Dam will go through the spillway rather than the juvenile bypass, corner collector, or turbine units, and 3) exposure to increased levels of TDG in Bonneville Reservoir and for at least 35 miles below Bonneville Dam.

Increased spill has been correlated with increased fallback behavior at Bonneville Dam for steelhead (Boggs et al. 2004), and fallback is a concern because increased fallback has been demonstrated to reduce conversion to natal tributaries for adult salmonids (Keefer et al. 2005). While the additional spill could increase the overall proportion of adult LCR steelhead that fallback, the reduction in flow through the powerhouse could reduce the proportion of LCR steelhead that fall back through turbine units, which is the lowest survival route for adult salmonids to pass (Normandeau et al. 2014). The overall effect to adult survival and conversion success associated with the increase in spill is difficult to quantify with the existing information, but any impacts associated with an increase in spillway fallback are likely to be outweighed by a reduction in turbine fallback and have minimal overall impact to adult survival.

Downstream passage of juvenile steelhead through the spillway as compared to the bypass or corner collector could result in slightly lower direct survival rates based on the relative survival estimates of these routes of passage (Ploskey et al. 2012). However, higher spill will also result in fewer LCR steelhead passing through turbines, and because spillway survival is higher than turbine survival at most dams (Fredricks 2017), the consequence of more fish passing through the spillway could positively benefit population-level survival. Overall, the difference in direct project survival at Bonneville Dam will likely be minimal (<1 percent change) over baseline, however, the CSS study hypothesizes that increased spill will substantially reduce latent mortality of populations moving downstream through the mainstem dams (FPC 2020).

Compared to recent hydropower operations,[384] increased spill levels from April 10 to June 15 will increase the exposure of adult spring migrating adults and smolts to higher concentrations of TDG. The increased exposure is likely to affect the four populations of LCR steelhead within Bonneville Reservoir and the populations in the lower gorge that are nearest to Bonneville Dam, though increased TDG levels can be measured for at least 35 miles downstream of the dam. Exposure to elevated TDG (up to 125 percent) as a result of increased juvenile fish passage spill may negatively affect individual smolts but should have little, if any, substantive effect on

[384] From 2008 to 2017, the hydropower operation targeted 100 kcfs spill. In 2018, spill levels were increased to the 120 percent TDG limit (in the tailrace of Bonneville Dam).

juveniles migrating swiftly past Bonneville Dam and its tailrace, especially considering the limited duration of this proposed action. Adults could be exposed to elevated TDG levels for hours or days as they seek out fishway entrances in the tailrace of Bonneville Dam spillway. However, while some impacts to LCR steelhead are likely to occur due to the exposure of increased TDG levels, the information suggests the negative effects to survival are likely to be very limited due to limited exposure time (Fredricks 2017), depth compensation (Weitkamp et al. 2003), and considering that a relatively low proportion of LCR steelhead adults migrate in the spring.

The proposed operations at Libby and Hungry Horse Dams should not have any substantial effect on Columbia River summer flow. The proposed operation at Grand Coulee Dam will have a very small effect on Columbia River flow, primarily during August, and should not affect juvenile migration or survival because these fish do not migrate in summer. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

The proposed operations at Libby and Hungry Horse Dams should not have any substantial effect on summer flow. The proposed operation at Grand Coulee Dam will have a very slight effect on flow, primarily in August, but will be too small to affect adult migration or survival. The proposed operation at Dworshak Dam should not affect adults because any potential flow reduction would occur in high flow years during the spring, which is not when these adults migrate.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. This change would affect LCR steelhead adults that will be migrating in August by improving adult ladder attraction conditions and reducing fallback rates. However, individuals that fell back would experience greater risk because they would be more likely to pass via turbines and juvenile bypass systems instead of the spillway.

Maintenance of fish ladders, screens, bypass systems, and turbine units will occur along with dredging and rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of juvenile LCR steelhead present and these effects will occur at extremely low levels similar to what was observed in the recent past. Some winter migrating LCR steelhead adults will be present during maintenance activities and could be handled, delayed, or killed in limited circumstances. Efforts to maintain at least one available fish ladders will continue to allow LCR steelhead adults to pass. Maintenance activities have been developed through FPOM to avoid impacts and may be modified if evidence indicates elevated delay and mortality are occurring. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative ladders, attraction, or turbine unit priorities) and the efficient return FPP protocol will likely minimize these impacts.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (USACE et al. 2020). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for adult and juvenile salmonids passing through the turbine units, but the number of LCR steelhead affected should be extremely low. Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure and improve ladder attraction conditions for adult LCR steelhead, but would also slightly reduce turbine unit survival for adult and juvenile salmonids passing through the turbine units, and would also increase powerhouse passage rates for juveniles. These flow levels would be expected to occur in up to 5 to 10 percent of the years at Bonneville Dam; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur. Operating turbine units above the 1 percent efficiency resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is an average of 8 to 30 hours per project, with a maximum of 8 to 80 hours per project, for lower Columbia River dams, from April through June. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. Overall adult survival rates of LCR steelhead originating or migrating above Bonneville Dam should not be measurably reduced at the population, MPG, or DPS level as a result of the proposed turbine unit operations above 1 percent peak efficiency range. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of LCR steelhead through Bonneville Dam, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population, MPG, or DPS level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

2.11.3.1.2 Predation Management and Monitoring Actions

The Corps' program to install and operate sea-lion excluder gates at Bonneville Dam will continue and is likely to positively affect the four populations of LCR steelhead that pass upstream of Bonneville Dam. Likewise, the Corps' and BPA's support of sea-lion hazing, dissuasion, and removal efforts from the area downstream of Bonneville are likely to continue to reduce adult mortality (compared to mortality rates if these actions were not taken). These effects were described in the Environmental Baseline section and are expected to continue.

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. This fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the numbers of steelhead, including some from the LCR steelhead DPS, handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy), will be no more than 100 adults and 600 juveniles per year, system-wide. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams as described in the proposed action (BPA et al. 2020). Since the likelihood of the Dam Angling Program being implemented at Bonneville Dam is not is not reasonably certain to occur, it is unlikely that the program will have an effect on the abundance of LCR steelhead. We estimate that no more than one adult and 20 juvenile steelhead will be caught in the Dam Angling Program per year, but these incidental catches are unlikely to include any LCR steelhead.

The Action Agencies will continue to implement the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions are likely to continue current levels of predation at this colony, which, in the case of Caspian terns, is an average annual reduction of 4.8 percent compared to the pre-colony management period. However, ocean conditions, including compensatory effects, such as the number and behavior of predators and competition for prey, will determine whether this reduction in tern predation influences adult returns. Although there appears to have been a small decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 5.4 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, we expect that cormorant predation in the estuary may be an increasingly important source of mortality for LCR steelhead.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none have been proposed at this time.

The Action Agencies will also continue to implement, and improve as needed, the avian predation deterrence measures at the tailraces of lower Columbia River dams, which address another source of mortality for juvenile LCR steelhead emigrating from populations in Bonneville Reservoir. These measures will continue to reduce predation on juvenile steelhead, although Zorich et al. (2012) were unable to quantify the amount of protection.

2.11.3.1.3 Habitat Actions

For LCR steelhead populations that have been negatively affected by CRS operations and maintenance, the Action Agencies will provide funding and/or technical assistance for tributary habitat improvement actions consistent with recovery plan implementation priorities and other regional efforts, as funding allows. If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could benefit the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for LCR steelhead as part of this proposed action, or proposed such actions in a manner that would allow us to meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential actions in our jeopardy analysis.

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to LCR steelhead as they migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty about predicting the timing and accomplishment of habitat restoration actions and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway. Continued implementation and evaluation of this monitoring program will either confirm that these floodplain reconnections are enhancing conditions for yearling salmonids, such as LCR steelhead as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during implementation of the proposed action and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during implementation of the proposed action, increasing the flux of insect and amphipod prey to the mainstem migration corridor for juvenile LCR steelhead. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[385] of all LCR steelhead populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.11.3.1.4 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for the impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail within the site-specific biological opinions referenced therein (see Section 2.11.2.7). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.11.3.1.5 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult SRB steelhead are likely to be present in shallow shoreline areas, an unknown portion of the DPS will continue to be stunned, harmed or possibly even killed. At

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[385] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile steelhead opportunities to move into wetland habitats for food and refuge from predators. Moreover, the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the LCR steelhead DPS.

present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this DPS that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[386]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of LCR steelhead will be affected each year:

- Activities associated with the Smolt Monitoring Program and the CSS:
  - One hatchery and one natural-origin adult will be handled.
  - One hatchery and one natural-origin adult will die.
  - Zero hatchery and 1,686 natural-origin juveniles will be handled.
  - Zero hatchery and three natural-origin juveniles will die.
- Activities associated with all other RME programs:
  - 100 hatchery and 200 natural-origin adults will be handled.
  - Ten hatchery and 10 natural-origin adults will die.
  - 5,000 hatchery and 1,814 natural-origin juveniles will be handled.
  - 50 hatchery and 32 natural-origin juveniles will die.

[386] Ongoing and future discussions are expected to lead to substantial reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program will, on average, affect less than 2 percent (1.46 percent) of the natural-origin adult (recent, 5-year average) run (arriving at mouth of the Columbia River) and 1 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to much less than 1 percent of estimated DPS abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the small effects of the RME programs on abundance are acceptable and warranted.

2.11.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small reduction in obstructions at lower Columbia River dams for individuals from four of the 23 populations of LCR steelhead DPS—Wind Summer run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run. Adults from the two summer-run populations in the Gorge stratum that enter the Columbia River during periods of gas cap spill are likely to experience a small increase in obstructions due to an increased rate of involuntary fallback over the spillways. Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary. Effects of the proposed action on PBFs are described in Table 2.11-7.

Table 2.11-7. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the LCR steelhead DPS.

PBF	Effect of the Proposed Action
Freshwater spawning sites	Continued inundation of some steelhead spawning sites in the lower ends of tributaries to Bonneville Reservoir (reduced availability of sites for spawning, incubation, and larval development) for four of 23 populations) We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat will be available within the proposed 5-foot operating range.
Freshwater rearing sites	Continued inundation of some steelhead rearing sites in the lower reaches of tributaries to Bonneville Reservoir (reduced availability of freshwater rearing sites for four of 23 populations). We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat will be available within the proposed 5-foot operating range. See also "estuarine areas."
Freshwater migration corridors	Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative

PBF	Effect of the Proposed Action
	effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. Proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not change the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring, when adult LCR steelhead from summer-run populations are migrating and warmer temperatures in the late summer and fall. In general, cooler spring temperatures will not adversely affect the functioning of the mainstem as a migration corridor for juveniles or for adults from summer-run populations. Adults from winter-run LCR steelhead populations enter the Columbia River beginning in November, after temperatures have cooled. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (ongoing reduction in “natural cover”). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Further increase in TDG up to 125 percent of atmospheric saturation during flexible spring spill in the gorge area and at least 35 miles downstream of Bonneville Dam during flexible spring spill. The effect on water quality in terms of an increase in the incidence of GBT is likely to be very small. The Corps will continue to protect water quality by using best management practices to minimize accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. The flexible spring operation to 125 percent TDG will increase obstructions in the adult migration corridor by a small amount by increasing the risk of fallback over project spillways for the four upper Gorge populations. Increased spill levels resulting from the flexible spring spill operation (up to 125 percent TDG) are likely to further reduce juvenile travel time by a small amount compared to recent operations, thereby reducing exposure to predators in the The Dalles Dam to Bonneville reach (reduction in excessive predation in the juvenile migration corridor) compared to recent operations for the four populations with spawning areas above Bonneville Dam. Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (reduced obstructions) for the four populations with spawning areas above Bonneville Dam. However, by increasing powerhouse flows, it will increase obstructions for juveniles from these populations by a small amount. This operation would not affect the functioning of the juvenile and adult migration corridors below the tailrace of Bonneville Dam. Continued small increases in obstructions for adult steelhead during routine outages of fishways or turbine units at Bonneville Dam. Very small increases

PBF	Effect of the Proposed Action
	in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities. Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back over spillways for adults and degraded tailrace conditions for juveniles). Small reductions in water quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Continued deployment of sea-lion exclusion devices and hazing at Bonneville Dam to maintain the protection of adult steelhead that reach the fishways at current levels (ongoing reduction in predation). Continued implementation of the NPMP to maintain fish predation (ongoing reduction in predation) at current levels. Continued implementation of the avian predation deterrence operations to maintain predation on juvenile steelhead in project tailraces at current levels (ongoing reduction in levels of predation).
Estuarine areas	Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels; juvenile and adult forage. This will increase access to prey for yearling steelhead, which primarily remain in the mainstem. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.11.4 Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area’s future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.11.1), Environmental Baseline (Section 2.11.2), and Effects of the Action (Section 2.11.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including LCR steelhead.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of the activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.11.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.11.5.1 Species

The LCR steelhead DPS is made up of 23 populations grouped into four MPGs based on combinations of ecoregion (Cascade and Gorge) and life-history type (winter-run and summer-run): Cascade Winter (14 populations), Cascade Summer (four populations), Gorge Winter (three populations), and Gorge Summer (two populations). Sixteen populations are considered to be at high or very high overall risk, six are rated at moderate risk, and one (Wind summer-run) is rated at low risk. LCR steelhead are at very low population levels primarily due to degraded spawning and rearing habitat in tributaries (including blockages by hydropower developments), harvest, and hatchery production. Overall, abundance has remained relatively stable (but low) for winter-run populations (with the exception of the Clackamas and Sandy River populations winter-run populations). The abundance of summer-run steelhead populations has also been relatively stable (but low), with recent surveys, where available, showing a drop in abundance since 2014. Compared to earlier estimates, the most recent estimates of population abundance (2014 to 2018 geomeans) indicate no clear trends, with some populations increasing, some decreasing, and others staying at similar levels. Recent poor ocean conditions associated with a marine heatwave and its lingering effects have likely contributed to lower than average survival rates for some populations in recent years. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants.

Five populations (three Gorge winter and two Gorge summer) of LCR steelhead are affected by upstream and downstream passage at Bonneville Dam. Two of these populations within the Columbia Gorge MPG have an overall risk rating of Low (Wind summer) or Medium (Hood winter), which is equal to or better than the risk ratings of any population downstream of Bonneville Dam, indicating that passage losses at the project are likely not the most important factor affecting the VSP status of the affected populations. The removal of Powerdale Dam (Hood River) and Condit Dam (Upper Gorge) should continue to improve VSP ratings for these populations.

Structural and operational improvements at Bonneville Dam should improve passage conditions for juvenile LCR steelhead from the five populations that spawn upstream of Bonneville Dam. The proposed 125 percent TDG spring spill operation should further increase spill levels at

Bonneville Dam (limited to 150 kcfs) which will increase juvenile exposure to TDG beginning April 10. The potential for negative effects from increased TDG may be greater for juvenile steelhead than for other species because they tend to migrate higher in the water column; however, they typically occur deeper than 1 to 2 meters from the surface so depth compensation would still ameliorate effects of high TDG. In 2020, implementation of spring spill up to 125 percent TDG did not cause GBT symptoms at levels of concern at Bonneville Dam. Other operations (e.g., Upper Columbia operations to better protect resident species, Dworshak Dam winter operations to reduce TDG in the lower Clearwater River, operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, etc.) could, collectively, have a small, negative effect, especially on juvenile migrants. However, these effects should not measurably alter juvenile survival rates, and overall juvenile passage survival should be maintained or should increase slightly as a result of this proposed operation.

Maintenance of fish ladders, screens, bypass systems, and turbine units will occur along with dredging and rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of juvenile LCR steelhead present and these effects will occur at extremely low levels similar to what was observed in the recent past. Some winter migrating LCR steelhead adults will be present during maintenance activities and could be handled, delayed, or killed in limited circumstances. Efforts to maintain at least one available fish ladders will continue to allow LCR steelhead adults to pass. Maintenance activities have been developed through FPOM to avoid impacts and may be modified if evidence indicates elevated delay and mortality are occurring. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative ladders, attraction, or turbine unit priorities) and the efficient return FPP protocol will likely minimize these impacts.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing condition. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies’ estuary habitat improvement program, which has the potential to contribute to improving LCR steelhead abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this DPS. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan and the Double-crested Cormorant Management Plan, as well as hazing at Bonneville Dam. For LCR steelhead, we expect that management of the East Sand Island tern colony is reducing mortality by a small amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that likely prey on juvenile LCR steelhead are also present in the hydrosystem reach. The NPMP and dam angling program are expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested Cormorant Management Plan, these programs will maintain current (reduced) levels of predation, creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on LCR steelhead in the lower Columbia River and estuary has increased substantially with recent increases in the abundance of sea lions, especially in the spring. Estimated pinniped consumption of steelhead (all DPSs) at Bonneville Dam is less than 2 percent during the fall and winter, and has ranged from 2 to 11 percent (2009 to 2018) during the spring. Sea lion predation downstream of Bonneville Dam, including the estuary, continues to negatively affect the productivity and abundance of LCR steelhead.

The management of LCR steelhead hatchery programs has improved substantially compared to historical operations. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of LCR steelhead.

Harvest rates on LCR steelhead in fisheries have decreased compared to historical levels. Harvest rates for steelhead populations upstream of Bonneville Dam should not exceed 15 percent, and harvest impacts to the other populations in the DPS should average less than 1 percent.

As described in Section 2.11.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area considered for LCR steelhead are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect LCR steelhead in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of LCR steelhead as moderate. We generally expect that abundance could decrease and extinction risk increase as a result of climate change.

Summer-run adults could potentially respond temporally to changing environmental conditions by migrating and spawning later in time. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or flood events). Juvenile emergence and rearing could potentially become "out-of-sync" with nursery conditions in streams. Yearling migrants will be negatively affected because they would be exposed to higher summer temperatures. Though the quality of information is mixed, sensitivity in the marine stage is likely high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur. These climate change consequences are not caused by the proposed action. In simple terms, even if the adult abundance declines somewhat as a result of climate change, which will make recovery of this ESU somewhat more challenging, it will have declined no more so as a result of the proposed action.

The proposed action includes conservation measures to mitigate the potential adverse effects of the action, in many cases by addressing limiting factors for survival and recovery. These measures include estuary habitat improvement and predator management actions that should benefit VSP parameters, thus reducing the expected abundance declines caused by climate change. Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this DPS (e.g., dam passage survival, population productivity, degraded estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.)

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity, especially for those populations upstream of Bonneville Dam. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., estuary habitat, predation, etc.). For the five Columbia Gorge populations, evidence suggests that these actions have contributed to improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The proposed action carries forward structural and operational improvements at Bonneville Dam since 2008 and improves upon them and ecosystem functions should continue to increase in estuary habitats where improvement actions occur.

Climate change is a substantial threat to LCR steelhead, especially during the marine rearing phase of their life cycle. The proposed action should not exacerbate either the scope and/or severity of those impacts.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of LCR steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of LCR steelhead.

2.11.5.2 Critical Habitat

Critical habitat for LCR steelhead encompasses eight subbasins in Oregon and Washington containing 38 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for steelhead are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2013b) and most of these watersheds have some, or a high, potential for improvement. The removal of some large tributary dams has improved habitat quality in spawning and rearing areas in the lower reaches of these streams and removed obstructions for LCR steelhead populations with higher elevation spawning areas. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns.

The environmental baseline includes a broad range of past and present actions and activities, including effects of the hydrosystem, that have affected the conservation value of critical habitat in the juvenile and adult migration corridors for LCR steelhead. Some of these past effects will continue: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and for four populations with spawning areas above Bonneville Dam, longer travel times and passage delays (obstructions in the migration corridor). These factors have increased the likelihood of excessive predation on some juvenile and adult LCR steelhead and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The Action Agencies have reduced effects of their operations on travel time and survival for juveniles from the five Columbia Gorge populations by increasing the level of spring spill at Bonneville Dam. We expect the flexible spring spill to 125 percent TDG to further reduce the effect of Bonneville Dam as an obstruction by a small amount. Any effect on water quality in terms of additional risk of GBT is likely to be moderate for juvenile steelhead and small for adults. Higher spill levels will increase obstructions for adults by a small amount due to the increased risk of fallback over the spillway.

The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors for this species. Operating the turbine units at Bonneville and The Dalles Dams above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction for adults from the four gorge populations (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions for adults and juveniles by a small amount because some adults will fall back or juveniles will move downstream through turbines. This operation will not affect the functioning of the juvenile and adult migration corridors below the tailrace of Bonneville Dam. The thermal inertia created by the CRS reservoirs will continue to negatively affect temperatures (water quality) in late summer and fall, but this does not overlap with either the juvenile or adult migration periods for LCR steelhead.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors. Thus, the proposed action is not likely to further limit water quantity or water quality or to increase obstructions in the juvenile migration corridor by a meaningful amount.

The Action Agencies will continue to implement pinniped control measures to reduce predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the lower Columbia River, and the predation management programs for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will maintain the levels of predation within the juvenile and adult migration corridors that were achieved in recent years, although cormorant predation rates may further increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the estuary, many of these funded through the CRS program. The Action Agencies propose to continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling steelhead migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of LCR steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of LCR steelhead designated critical habitat.

2.11.6 Conclusion

After reviewing and analyzing the current status of LCR steelhead and its critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR steelhead or destroy or adversely modify its designated critical habitat.

2.12 Lower Columbia River (LCR) Coho Salmon

This section applies the analytical framework described in Section 2.1 to the LCR coho salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the LCR coho salmon ESU or destroy or adversely modify its critical habitat.

2.12.1 Rangewide Status of the Species and of Critical Habitat

The status of the LCR coho salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.12.1.1 Status of the Species

2.12.1.1.1 Background

On June 28, 2005, NMFS listed the LCR coho salmon ESU as a threatened species (70 FR 37160). The threatened status was reaffirmed on April 14, 2014. The most recent status review, in 2016, concluded that this ESU should retain its threatened status (81 FR 33468). Critical habitat was designated on January 24, 2016 (81 FR 9252). The summary that follows describes the status of LCR coho salmon. More information can be found in the recovery plan (NMFS 2013b) and the most recent status review (NMFS 2016i) for this species.[387]

The LCR coho salmon ESU includes naturally spawned coho salmon originating from the Columbia River and its tributaries downstream from the White Salmon and Hood Rivers (inclusive) and any such fish originating from the Willamette River and its tributaries below Willamette Falls (Figure 2.12-1). The ESU also includes coho salmon from 21 artificial

[387] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

propagation programs (70 FR 37160).[388] The ESU contains 24 independent populations in three ecological regions (Coast, Cascade, and Gorge); each of these three ecological regions is considered an MPG.[389]

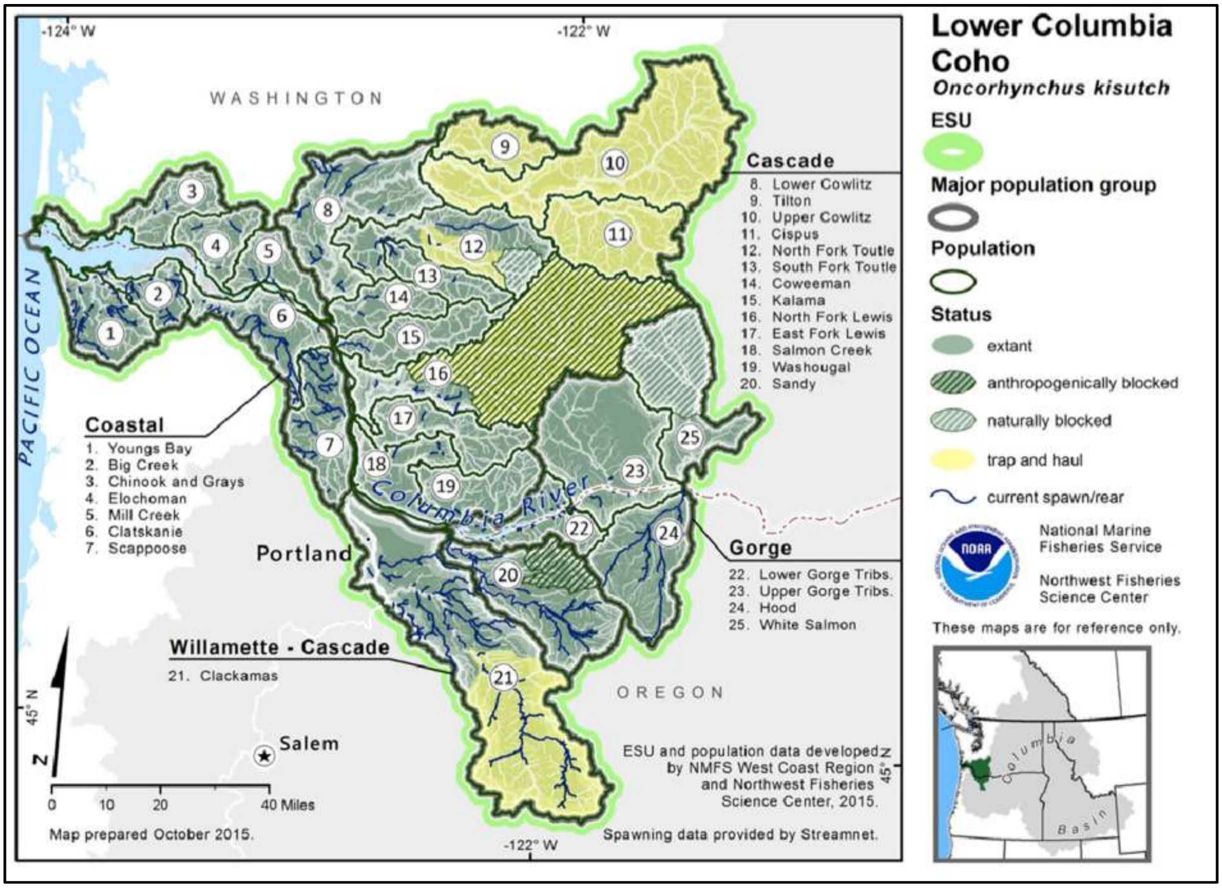

Figure 2.12-1. Map of the LCR coho salmon ESU's spawning and rearing areas, illustrating populations and major population groups.

[388] Grays River Program; Peterson Coho Project; Big Creek Hatchery Program (ODFW Stock #13); Astoria High School Salmon-Trout Enhancement Program (STEP) Coho Program; Warrenton High School STEP Coho Program; Cowlitz Type-N Coho Program in the Upper and Lower Cowlitz Rivers; Cowlitz Game and Anglers Coho Program; Friends of the Cowlitz Coho Program; North Fork Toutle River Hatchery Program; Kalama River Type-N Coho Program; Kalama River Type-S Coho Program; Lewis River Type-N Coho Program; Lewis River Type-S Coho Program; Fish First Wild Coho Program; Fish First Type-N Coho Program; Syverson Project Type-N Coho Program; Washougal River Type-N Coho Program; Eagle Creek National Fish Hatchery Program; Sandy Hatchery Program (ODFW Stock #11); and the Bonneville/Cascade/Oxbow Complex (ODFW Stock #14) Hatchery Program. In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species, including LCR coho salmon (81 FR 72759). The proposed changes for hatchery program inclusion in this ESU were to remove the Kalama River Type-S Coho Program and add the Clatsop County Fisheries/Klaskanine Hatchery and Clatsop County Fisheries Net Pen Programs. We expect to publish the final revisions in 2020. For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c).

[389] The W/LC TRT used the term "strata" to refer to these population groupings, which are significant in identifying delisting criteria. The strata are analogous to the "major population groups" defined by the ICTRT. For consistency, we use the term "major population group" throughout this opinion.

2.12.1.1.2 Life-History and Factors for Decline

LCR coho salmon are typically categorized as either early- or late-returning stocks. Early-returning adult coho salmon enter the Columbia River in mid-August and begin entering tributaries in early September, with peak spawning from mid-October to early November. Late-returning coho salmon pass through the lower Columbia from late September through December and enter tributaries from October through January. Most spawning occurs from November to January (LCFRB 2010). Coho salmon generally spawn in intermediate positions in tributaries, typically further upstream than chum or fall-run Chinook, but often downstream of steelhead or spring-run Chinook (ODFW 2010). They particularly favor small, rain-driven, lower elevation streams characterized by relatively low flows during late summer and early fall, and increased river flows and decreased water temperatures in winter (LCFRB 2010). On their return, adult fish often mill near river mouths or in lower river pools until the first fall freshets occur (LCFRB 2010). Juveniles typically rear in freshwater for more than a year. After emergence, coho salmon fry move to shallow, low-velocity rearing areas, primarily along stream edges and inside channels. Juvenile coho salmon favor pool habitat and often congregate in quiet backwaters, side channels, and small creeks with riparian cover and woody debris. Side-channel rearing areas are particularly critical for overwinter survival, which is a key regulator of freshwater productivity (LCFRB 2010).

It is impossible to accurately estimate the decline in LCR stocks of coho salmon, but a NMFS review estimated that the runs may have been reduced to less than 5 percent of historical levels by the late 1950s (Johnson et al. 1991). The drastic decline in coho salmon abundance initiated a widespread hatchery enhancement program after 1960. This program increased coho salmon abundance in the Columbia River to near historical levels, but the causes of the original decline were not addressed by this extensive hatchery production. Overharvest, habitat blockage and destruction, and other activities detrimental to natural production continued. The result was a continued decline in naturally spawning runs while harvest exploitation of hatchery fish continued at increased levels (Johnson et al. 1991).

In the early 1980s, it was estimated that less than 25,000 coho salmon were spawning naturally in the Columbia River basin, and these fish were thought to be mainly feral hatchery fish and returns from hatchery outplants in streams away from hatcheries, although some were naturally produced. The NMFS review found no data to suggest that these numbers had changed significantly by the time of their review, and noted that ODFW estimated that there might be less than 195 coho salmon in Oregon, existing in small, isolated populations in the Lewis and Clark and Sandy River systems (Johnson et al. 1991).

2.12.1.1.3 Recovery Plan

The ESA recovery plan for LCR coho salmon (NMFS 2013b) includes delisting criteria for the ESU, along with identification of factors currently limiting its recovery, and management actions necessary for recovery. The biological delisting criteria are based on recommendations by the

W/LC TRT.[390] They are hierarchical in nature, with ESU-level criteria based on the status of natural-origin LCR coho salmon assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the ESU will require sufficient improvement in its abundance, productivity, spatial structure, and diversity.

2.12.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within an ESU based on parameters of abundance, productivity, spatial structure, and diversity (these parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans, and based on recommendations of the W/LC TRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low extinction risk. For LCR coho salmon, recovery requires improving all three MPGs to a high probability of persistence or a probability of persistence consistent with their historical condition.

Earlier status reviews of LCR coho salmon raised concerns that most of the historical populations in the ESU appeared to be either extirpated or nearly so, and that the two populations with any significant production (Sandy and Clackamas Rivers) were at appreciable risk because of low abundance, declining trends, and failure to respond after a dramatic reduction in harvest. The large number of hatchery coho salmon in the ESU was also considered an important risk factor (Good et al. 2005, McElhany et al. 2007). The extreme loss of naturally spawning populations, low abundance of extant populations, diminished diversity, and fragmentation and isolation of the remaining naturally produced fish conferred considerable risks to LCR coho salmon.

These previous status reviews, however, lacked adequate quantitative data on abundance and hatchery contribution for a number of populations. Anecdotal information provided during these reviews suggested that hatchery-origin fish dominated many of the populations and that natural productivity was very low. More recent surveys provide a more accurate understanding of the status of these populations; however, with only 2 or 3 years of data, it is not possible to determine whether there has been a true improvement in status. It is, however, certain that the contribution of naturally produced fish is much higher than previously thought. Overall, the estimated changes in status for coho salmon populations noted in the most recent status review reflect improvements in abundance, diversity, and spatial structure, as well as monitoring (NWFSC 2015).

[390] The recovery plan also includes “threats criteria” for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

NMFS' most recent status review (NMFS 2016i) found that long-term abundances were generally stable or improving. In the Coast MPG, the Scappoose Creek population exhibited a positive abundance trend and contained few hatchery-origin fish. Similarly, the Clatskanie River population had moderate numbers of naturally produced spawners, with proportionately few hatchery-origin spawners. The initiation of spawner surveys in Washington tributaries also indicated the presence of moderate numbers of coho salmon, with total abundances in the hundreds to low thousands of fish, a substantial proportion of which were naturally produced.[391] Oregon tributaries in this MPG had abundances in the hundreds of fish, the majority of which were naturally produced. In the Cascade MPG, abundance trends for the Sandy and Clackamas populations remained stable and positive, respectively. There were also substantial returns of natural-origin coho salmon to the Tilton and Upper Cowlitz/Cispus Rivers in 2014. Where it was possible to calculate trends for populations in this MPG, they were generally stable. In the Gorge MPG, natural-origin abundances were low, with hatchery-origin fish contributing a large proportion of the total number of spawners, most notably in the Hood River (NWFSC 2015).

In terms of diversity effects, the most recent status review (NMFS 2016i) noted that hatchery releases had remained relatively steady since 2005, and that for most populations, the proportion of hatchery-origin fish spawning naturally exceeded the criteria set in the recovery plan. Efforts to shift production into localized areas (e.g., Youngs Bay and Big Creek) to reduce the influence of hatchery fish on other nearby populations (e.g., Scappoose and Clatskanie) were considered in transition. Reductions were also noted in the number of hatchery-origin juvenile coho salmon released into the Sandy River, and integrated hatchery programs had been developed in a number of basins to limit the loss of genetic diversity (NWFSC 2015).

The most recent status review (NMFS 2016i) also described a number of large-scale efforts to improve access to habitat, one of the primary metrics for spatial structure. On the Hood River, Powerdale Dam was removed in 2010. Condit Dam, on the White Salmon River, was removed in 2011 (although current monitoring efforts did not include coho salmon surveys, so the most recent status review noted that the extent of recolonization was unknown). Trap and haul fish passage operations were begun on the Lewis River in 2012, although juvenile passage efficiencies were still considered relatively poor. In addition, efforts to provide downstream juvenile passage at the Cowlitz Dam complex began in the 1990s, and the most recent status review noted that there had been a gradual increase in the numbers of naturally produced coho salmon adults. A trap and haul program was also in use to maintain access to the North Toutle River above the sediment retention structure. The most recent status review noted that many of these actions had occurred too recently to be fully evaluated, and where data were available they were not able to be assessed (NWFSC 2015, NMFS 2016i). The most recent status review also noted that while recent dam removals and the initiation of trap-and-haul programs had eliminated most major spatial structure limitations, smaller migrational barriers such as culverts may still limit spatial structure.

[391] These new data series for Washington tributaries were too short to calculate meaningful population trends.

The most recent status review (NWFSC 2015, NMFS 2016c) concluded that the status of a number of coho salmon populations had changed since earlier reviews. Changes in abundance and productivity, diversity, and spatial structure were generally positive; however, it remained unclear whether this was due to the improved level of monitoring, or the effects of recent recovery efforts, or both. Despite the improved information and recent improvements, the LCR coho salmon ESU most likely remained at moderate risk of extinction (NMFS 2016i). Furthermore, at the time of the most recent status review, none of the MPGs had met their recovery goals, and most populations still required substantial improvements to reach their recovery goals (Table 2.12-1). Abundances were still relatively low, and most populations remained at moderate or high risk of extinction. For the lower Columbia River region, land development and increasing human population pressures are likely to continue to degrade habitat, especially in lowland areas.

Table 2.12-1 lists the MPGs and populations in this ESU and summarizes their abundance/productivity, spatial structure, diversity, and overall population risk status at the time of the most recent status review (NWFSC 2015, NMFS 2016i); it also summarizes their target risk status for delisting (NMFS 2013b).

Table 2.12-1. LCR coho salmon population-level risk for abundance/productivity (A/P), spatial structure, diversity, overall extinction risk as of the most recent status review (NWFSC 2015, NMFS 2016i), and recovery plan target status (NMFS 2013b). Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH). The populations that spawn upstream of Bonneville Dam are highlighted in gray.

Ecological Subregion	Population	A/P Risk Rating	Spatial Structure Risk Rating	Diversity Risk Rating	Overall Extinction Risk Rating	Recovery Plan Target Status
Coast Range	**Youngs Bay (OR)**	VH	VL	VH	VH	VH
	Grays/Chinook Rivers (WA)	VH	L	VH	VH	L
	Big Creek (OR)	VH	L	H	VH	VH
	Elochoman/Skamokawa creeks (WA)	VH	L	VH	VH	L
	Clatskanie River (OR)	H	VL	M	H	VL
	Mill, Germany, and Abernathy creeks (WA)	VH	L	H	VH	M
	Scappoose River (OR)	M	L	M	M	VL
Cascade Range	**Lower Cowlitz (WA)**	VH	M	M	VH	L
	Upper Cowlitz (WA)	VH	M	H	VH	L
	Cispus (WA)	VH	M	H	VH	L
	Tilton River (WA)	VH	M	H	VH	VH
	South Fork Toutle River (WA)	VH	L	M	VH	L
	North Fork Toutle River (WA)	VH	M	H	VH	L
	Coweeman River (WA)	VH	L	M	VH	L
	Kalama River (WA)	VH	L	LH	VH	H

Ecological Subregion	Population	A/P Risk Rating	Spatial Structure Risk Rating	Diversity Risk Rating	Overall Extinction Risk Rating	Recovery Plan Target Status
	North Fork Lewis River (WA)	VH	LH	H	VH	H
	East Fork Lewis River (WA)	VH	L	M	VH	L
	Salmon Creek (WA)	VH	M	VH	VH	VH
	Clackamas (OR)	M	VL	L	M	VL
	Sandy (OR)	VH	L	M	VH	L
	Washougal (WA)	VH	L	H	VH	M
Columbia Gorge	**Lower Gorge (WA, OR)**	VH	M	VH	VH	L
	Upper Gorge/White Salmon (WA)	VH	M	VH	VH	L
	Upper Gorge /Hood (OR)	VH	VL	H	VH	L

2.12.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the LCR coho salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. LCR coho salmon have been—and continue to be—affected by habitat degradation, hydropower impacts, harvest, and hatchery production (NMFS 2013b).

Impaired side channel and wetland conditions and degraded floodplain habitat have significant negative impacts on juvenile coho salmon throughout the ESU, while degraded riparian conditions and channel structure and form have negative impacts on both juveniles and adults of all populations. Extensive channelization, diking, wetland conversion, stream clearing, and, in some subbasins, gravel extraction have severed access to historically productive habitats, simplified remaining tributary habitats, and weakened the watershed processes that once created healthy ecosystems (NMFS 2013b).

Dam-related impacts vary throughout the ESU. Mainstem flow management alters flow volume and timing in the estuary, reducing access to peripheral habitat and changing the dynamics of the estuarine food web. As stream-type fish, juvenile coho salmon spend less time in the estuary than do ocean-type salmon, yet estuary habitat conditions do play a role in their survival, particularly those displaying less dominant life-history strategies. In addition, Bonneville Dam creates passage issues for the Upper Gorge/Hood and Upper Gorge/White Salmon populations, and the reservoir may have inundated historical spawning habitat. Tributary dams are a limiting factor in some subbasins, particularly the Cowlitz and Lewis subbasins (NMFS 2013b).

Harvest-related mortality was identified as a primary limiting factor for the ESU. For the period from 1970 to 1993, harvest rates averaged 82 percent, but since 2005, harvest impacts have been drastically reduced through measures such as mark-selective fisheries and time and area closures in both ocean and in-river fisheries (NMFS 2013b). Hatchery-related effects were also identified as a primary limiting factor for the ESU. Although production is reduced from the peak in the late 1980s, legacy effects of hatchery fish and current hatchery production continue to pose a threat to LCR coho salmon. It is likely that most coho salmon spawning naturally in the lower Columbia River are of hatchery origin (NMFS 2013b).

Birds, fish, and marine mammals also prey on LCR coho salmon in the lower Columbia River and, for those spawning above Bonneville Dam, in the reservoir (NMFS 2013b).

2.12.1.1.6 Information on Status of the Species since the 2016 Status Review

We do not have dam counts for this species comparable to those discussed in prior sections for interior basin salmon and steelhead, because most LCR coho salmon spawning takes place below Bonneville Dam. The best scientific and commercial data available are at the population level (Table 2.12-2) and indicate a mix of recent increases, decreases, and relatively static numbers of natural-origin and total spawners in 2014 to 2018 compared to the 2009 to 2013 period.[392] Therefore, the degree which abundance has been driven by below average ocean survival, as described for the interior Chinook salmon and steelhead species, or by a variety of environmental conditions and management actions in freshwater spawning and rearing habitat, appears to vary between populations.

Table 2.12-2. 5-year geometric mean of natural-origin spawner counts for LCR coho salmon. Number in parenthesis is the 5-year geometric mean of total spawner counts. "% change" is a comparison between the two most recent 5-year periods (i.e., 2014-2018 compared to 2009-2013). "NA" means not available. At the time of drafting this opinion, 2019 data were not available for any of the populations in this ESU. Source: Williams (2020e).

MPG	Population	1999-2003	2004-2008	2009-2013	2014-2018	% Change
Cascade	**Kalama River**	NA	NA	10 (278)	45 (232)	350 (-17)
	North Fork Lewis River	NA	NA	1196 (2133)	1409 (7373)	18 (246)
	Sandy River	NA	966 (1025)	1296 (1427)	1259 (1308)	-3 (-8)
	Clackamas River	1625 (2654)	2379 (4013)	3494 (4075)	3752 (4226)	7 (4)
	Coweeman River	NA	NA	2874 (3106)	2308 (2697)	-20 (-13)
	South Fork Toutle River	NA	NA	1580 (1878)	1554 (2068)	-2 (10)

[392] The upcoming 2021 status review is expected to include population-level adult returns through 2019, and the 5-year periods used for calculating geomeans will shift forward (i.e., the last period will include 2015 to 2019). Because 2014 adult returns represented a peak at the ESU level for some populations, shifting 2014 to the preceding 5-year grouping is likely to increase the negative percent change.

MPG	Population	1999-2003	2004-2008	2009-2013	2014-2018	% Change
	East Fork Lewis River	NA	NA	1822 (2080)	821 (1222)	-55 (-41)
	Lower Cowlitz River	NA	NA	3717 (4400)	3754 (4486)	1 (2)
	North Fork Toutle River	NA	NA	1092 (1628)	1133 (2038)	4 (25)
	Upper Cowlitz River	4095 (36296)	4881 (22031)	1122 (13084)	1011 (6403)	-10 (-51)
	Washougal River	NA	NA	527 (702)	192 (756)	-64 (8)
	Salmon Creek	NA	NA	1428 (1530)	1623 (1755)	14 (15)
	Tilton River	1099 (11802)	883 (4438)	1603 (5378)	2632 (5321)	64 (-1)
Columbia Gorge	**Lower Gorge Tributaries**	NA	NA	458 (559)	439 (541)	-4 (-3)
	Upper Gorge Tributaries	NA	NA	43 (59)	40 (53)	-7 (-10)
Coast Range	**Scappoose Creek**	NA	461 (474)	622 (622)	577 (583)	-7 (-6)
	Clatskanie River	NA	598 (617)	1033 (1091)	348 (469)	-6 (-57)
	Elochoman River	NA	NA	531 (1158)	744 (1180)	40 (2)
	Grays and Chinook Rivers	NA	NA	252 (1288)	357 (1172)	42 (-9)
	Mill, Abernathy, and Germany Creeks	NA	NA	526 (587)	843 (948)	60 (61)

Since 2016, observations of coastal ocean conditions indicate that recent outmigrant year classes have experienced below-average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict the drop in adult coho salmon returns observed through 2019 (Werner et al. 2017). Some of the negative impacts on juvenile salmonids had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 50-m surface layer) had not returned to normal (Harvey et al. 2019). Expectations for marine survival are relatively mixed for juveniles that reached the ocean in 2019 (Zabel et al. 2020).

NMFS will evaluate the implications for extinction risk of these more recent returns in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.12-2.

2.12.1.2 Status of Critical Habitat

NMFS (2016i) designated critical habitat for LCR coho salmon to include all estuarine areas and river reaches from the mouth of the Columbia River upstream to the confluence of the Hood River (50 CFR 226.212(t)). Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2013b) and have some, or high, potential for improvement. Similar to the discussion above regarding effects on the species, the status of critical habitat is likely to be affected by climate change, with predicted rising temperatures and alterations in stream flow patterns. Improved access to spawning and rearing habitat, and habitat restoration efforts, will help reduce those effects on critical habitat.

Of 55 designated HUC5[393] watersheds, NMFS (2016i) gave 34 a high rating, 18 a medium rating, and three a low rating for their value to the conservation (i.e., recovery) of the species. The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features NMFS (2016i) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2016i), as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.

[393] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country. A HUC5 is a five-unit (5 two-digit numbers) code. Examples are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the Wenatchee Basin, Washington.

- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction, with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.
- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.
- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case of freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Critical habitat also has been designated for LCR coho salmon in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. NMFS considers the estuary to have a high conservation value because it connects every population with the ocean and is used by rearing and migrating juveniles and by migrating adults

Human activities since the late 1800s have altered the form and function of the Columbia River estuary, reducing the quantity and quality of its PBFs. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained this environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in the mainstem navigation channel; and causeways have been constructed that restrict the position of tributary confluences.

In addition, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban use. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from upstream reservoirs have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of established flow variations in the Columbia River estuary through flow regulation may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has eliminated shallow-water habitats. Disconnecting the tidal river from its floodplain also prevented delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The remainder of the area designated as critical habitat is in the reservoir reach between Bonneville and The Dalles Dams. NMFS (2016i) designated critical habitat in eight occupied HUC5 watersheds in the Middle Columbia/Hood subbasin and rated five as having high and three as having medium conservation value. The reservoir itself is part of the high value rearing and migration corridor connecting upstream watersheds with downstream reaches and the ocean. Its conservation value has been affected by upstream and downstream passage at Bonneville. In most designated tributary watersheds, stream habitat, water quality, and watershed processes have been degraded by development and other land use activities.

2.12.1.3 Climate Change Implications for LCR Coho Salmon and Critical Habitat

One factor affecting the rangewide status of LCR coho salmon and aquatic habitat is climate change. The USGCRP[394] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[395] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

Likely changes in temperature, precipitation, and wind patterns (as well as sea-level rise in the lower estuary) have implications for survival and recovery of LCR coho salmon in both their freshwater, estuarine, and marine habitats and the PBFs of their critical habitat. While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (ISAB 2007). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1 to 4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure and coastal wetlands, and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

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[394] http://www.globalchange.gov

[395] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bioecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, certain management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations). Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends on both the characteristics of individual populations and the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable, so maintaining or promoting the diversity currently found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR coho salmon ESU.

Climate change would affect LCR coho salmon and critical habitat through physical and chemical changes to their habitats (e.g., increased water temperature, decreased ocean pH, changes in the timing and volume of stream flow). The physical and chemical changes may result in biological impacts such as, but not limited to, reduced ocean survival, changes in growth and development, and changes in run timing and spawning timing (Link et al. 2015). These biological changes can lead to changes in species productivity and abundance, distribution, food web structure, community structure, invasive species impacts, and biodiversity and resilience (Link et al. 2015).

Climate change would affect LCR coho salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Crozier et al. (2019) assessed LCR coho salmon as having a high vulnerability to the effects of climate change based on an analysis of the ESU's sensitivity (high) and exposure (high). Further, the species was determined to have a moderate adaptive capacity because its flexibility in the juvenile rearing period is likely similar to that of other coho salmon. Adults are less constrained in freshwater entry timing than California coho salmon, and thus could potentially respond temporally to changing environmental conditions (Crozier et al. 2019).[396]

In September, early-returning adults may encounter seasonally warm temperatures or low flows that delay entry into spawning tributaries. However, these adults will typically hold in estuaries or larger rivers and rapidly ascend tributaries to spawn when conditions become suitable (Clark et al. 2014). Seasonal drops in stream temperature and increases in discharge improve conditions for adult migration as well as egg incubation. Thus, incubating eggs of LCR coho salmon are unlikely to be exposed to excessively warm temperatures or desiccation.

[396] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results.

Because juveniles typically spend at least 1 year in freshwater, they can be stressed by warm stream conditions or low flows in summer (Ebersole et al. 2009) and by floods that may displace juveniles or reduce survival in winter (Nickelson et al. 1992). Ratings of high sensitivity in the juvenile freshwater stage and for exposure to stream temperatures reflected these findings and resulted in the juvenile freshwater stage ranking as a highly vulnerable life stage.

Though the quality of information is mixed, sensitivity in the marine stage is certainly high, and exposure to changing marine conditions—namely, high levels of ocean acidification—will occur. However, data quality used to evaluate climate-related threats was limited, and future evidence may alter these rankings.

2.12.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For LCR coho salmon, we focus our description of the environmental baseline on the portion of the action area where LCR coho salmon juveniles and adults are most exposed to the effects of the proposed action. We also include tributary habitat because these habitats, while not influenced by the proposed action, are primary drivers for the elements of VSP for LCR coho salmon, and thus are key habitats for recovery of the ESU, and are important to understand in the context of the proposed action.

The range of LCR coho salmon extends from the Columbia River and its tributaries downstream from the White Salmon (Washington) and Hood (Oregon) Rivers to the ocean. Therefore, the area where LCR coho salmon experience the greatest exposure to effects of the proposed action is the Columbia River from the tailrace of The Dalles Dam to the plume,[397] including tributary confluences in this reach to the extent that they are affected by proposed flow management and floodplain habitat mitigation actions.

[397] The Columbia River plume is defined as those waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

2.12.2.1 Mainstem Habitat

On the mainstem of the Columbia River, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.12-2). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

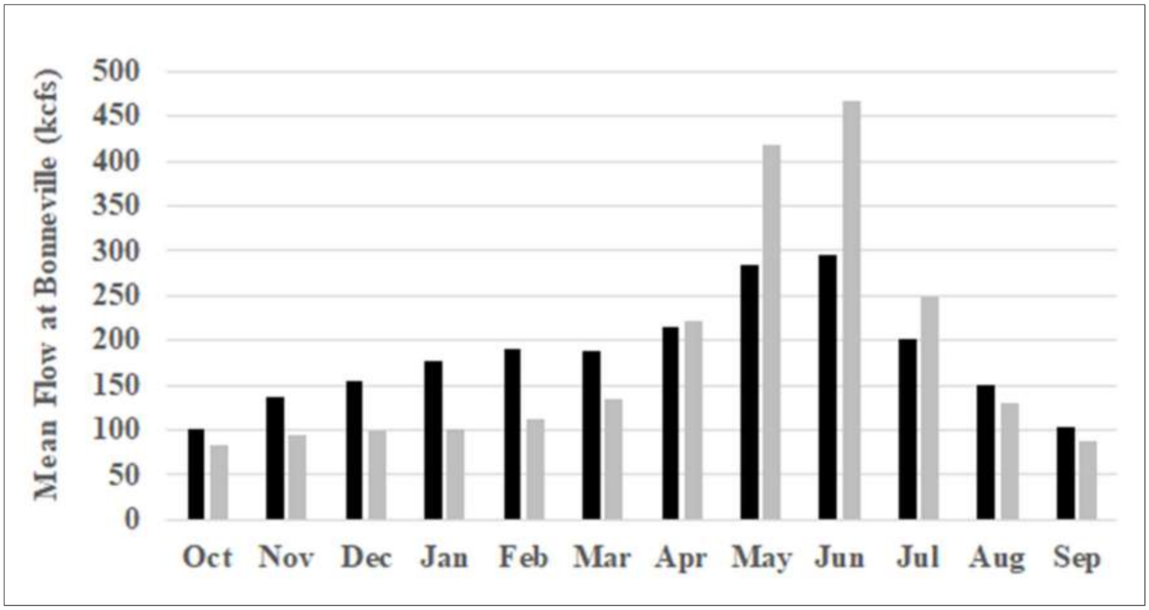

Figure 2.12-2. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[398] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et

[398] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile salmonids and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19th-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.12.2.2 Passage Survival

Only two out of 24 populations in this ESU—the Upper Gorge/Hood and Upper Gorge/White Salmon populations—are affected by passage conditions at Bonneville Dam.

There are no studies of downstream passage survival for juvenile LCR coho salmon. The survival of downstream migrants is likely to have improved over the last two decades due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2, and increases in the percentage of flow approaching the dam that goes over the spillway. Both of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). NMFS (2008a) estimated that the adult passage mortality rate for coho salmon at Bonneville Dam was similar to that of Snake River fall Chinook salmon (about 3.1 percent), which are present during the same time period. Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

2.12.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread

presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult LCR coho salmon is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of LCR coho salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead survival is a concern; because of temperature standard exceedances, portions of the lower Columbia River are on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.

- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges such as cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

TDG levels also affect mainstem water quality and habitat conditions. To facilitate the downstream movement of juvenile salmonids, state regulatory agencies issue waivers for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults is between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003, Pleizier et al. 2020).

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

2.12.2.3.1 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of LCR coho salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[399] with enhanced inspection protocols and prepares annual oil accountability reports that record quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

The EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[400] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic

[399] The lower Columbia River and lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

[400] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river.

activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials). The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.12.2.4 Project Maintenance

The Action Agencies have maintained the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Maintenance activities can be classified as routine scheduled maintenance, non-routine scheduled maintenance, and non-scheduled maintenance. Maintenance is necessary to ensure the reliability and safe operation of the dams and related fishway structures (e.g., fish ladders, screens, and bypass systems).

Maintenance that is planned and performed at regular intervals is referred to as routine scheduled maintenance. Examples of routine scheduled maintenance include: annual maintenance of fish ladders, screens, and bypass systems; turbine unit maintenance; and routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Routine scheduled maintenance is generally scheduled to occur when relatively few fish are present (generally December to March), is coordinated through FPOM to further minimize and avoid associated fish delay, injury, and mortality, and is typically included in the annual Fish Passage Plan.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include power plant modernization (e.g., turbine unit replacements) and major rehabilitations (e.g., repair of the spillway apron at Bonneville Dam and overhauling juvenile bypass systems).

Routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units have delayed and killed small numbers of adult LCR coho salmon that are migrating past the dams or overwintering within the fish facilities or turbine units, as they may become trapped in these locations. Although procedures are followed to minimize risks and to rescue adults that may become trapped in dewatered fishways, draft tubes, or other locations, small numbers of adults are trapped and a subset of these fish die each year from these activities. Routine dredging likely has minor temporary behavioral impacts (avoidance). Few to no juvenile LCR coho salmon have been affected by these activities, because they predominantly migrate from May to July.

Maintenance that is not planned is referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. The timing, duration, and extent of these events are unforeseeable. Unscheduled maintenance of turbine units or other structures such a spillbays can temporarily reduce hydraulic capacity at a project and result in higher than planned spill levels, higher TDG levels, and degraded tailrace conditions. These factors, depending upon the time of year when they occur, can delay, injure, or even kill adult and juvenile fish. Unscheduled maintenance needs are coordinated with NMFS and other co-managers through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT, to minimize potential negative effects on fish. Unscheduled maintenance can affect juvenile passage and survival, especially if these events occur during the spring freshet, but because they are sporadic in nature and coordinated through the in-season adaptive management process, the overall impact of these events is likely small and has not measurably affected juvenile reach survival estimates. The impact of unscheduled maintenance on juvenile and adult LCR coho has likely resulted in passage delay, handling, and some mortality during some outages, but measures to reduce these impacts such as providing attraction flow and alternative ladders and passage routes have minimized the impacts.

2.12.2.5 Tributary Habitat

Tributary habitat conditions for the LCR coho salmon ESU have in general been significantly degraded by an array of land uses, including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions (contributing to stream channel simplification, reduced bank stability, increased sediment load, and elevated water temperatures) (NMFS 2013b, 2016i). In addition, tributary dams have blocked or impeded passage and access to historical habitat for LCR coho salmon populations in the Cowlitz, Lewis, Clackamas, Sandy, Hood, and White Salmon subbasins. These dams are no longer a factor in the Sandy, Hood, and White Salmon subbasins since removal of Marmot and Little Sandy Dams (on the Sandy River, in 2008), Powerdale Dam (on the Hood River, in 2010), and Condit Dam (on the White Salmon River, in 2012). The Upper Gorge/Hood and Upper Gorge/White Salmon populations spawn above Bonneville Dam, so adults and juveniles in these populations must pass Bonneville Dam; in addition, the reservoir created when the dam was completed in 1938 may have inundated habitat for these two coho salmon populations (NMFS 2013b, 2016i).

Numerous tributary habitat protection and restoration actions have been implemented in recent years by local recovery planning groups, Federal and state agencies, tribal governments, local governments, conservation groups, private landowners, and other entities. These efforts have led to some local improvements in tributary habitat conditions (NMFS 2016i). However, degraded habitat conditions throughout the range of LCR coho salmon, particularly with regard to channel complexity, side channel and floodplain connectivity, water quality and hydrologic patterns, and toxic contamination from exposure to emerging and legacy chemicals, continue to negatively affect the abundance, productivity, spatial structure, and diversity of LCR coho salmon populations (NMFS 2016i). Continued land development and habitat degradation, in combination with the potential effects of climate change, may present a continuing strong negative influence (NWFSC 2015).

2.12.2.6 Estuary Habitat

The Columbia River estuary provides important migratory and rearing habitat for LCR coho salmon populations. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the estuary have been lost to diking, filling, and bank hardening combined with hydrosystem flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has eliminated some historical rearing habitat for coho salmon and reduced the production of wetland macrodetritus that supports salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary, such as those highlighted in the most recent 5-year review (NMFS 2016i), have improved access and connectivity to floodplain habitat. From 2007 through 2019, restoration sponsors implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents a more than a 2.5 percent net increase in a connectivity index of floodplain wetland habitats (Johnson et al. 2018). Although yearling coho salmon migrants are less likely to enter and rear in these areas, the large amounts of prey (particularly chironomid insects) exported from restored wetlands to the mainstem are actively consumed by these smolts. The resulting growth likely contributes to survival at ocean entry. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

As discussed in Section 2.12.2.3 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, the levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, and they are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.12.2.7 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect natural populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Hatchery production for LCR coho salmon has reduced the diversity and productivity of natural populations throughout the ESU. NMFS directs Federal funding to many of the hatchery programs that affect the LCR coho salmon ESU through the Mitchell Act. NMFS completed a biological opinion on its funding of the Mitchell Act program in 2017 (NMFS 2017i). As a result, several new reform measures have been or will be implemented, as described below. The implementation of these reform measures is expected to improve the status of the ESU:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could potentially be affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs, along with the installation of six new seasonal weirs because, in some tributaries, there

have been too many hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk; and

- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Hatchery releases have remained relatively steady at 10 to 17 million since the 2005 Biological Review Team report. The Hatchery Scientific Review Group (HSRG 2009) reported that overall hatchery production remains relatively high (15.7 million coho salmon released in tributary programs and 2.1 million released in Select Area Fisheries Enhancement (SAFE) areas). Most of the populations in the ESU contain a substantial number of hatchery-origin spawners. Recent efforts to shift production into localized areas (e.g., Youngs Bay and Big Creek) to reduce the influence of hatchery fish on other nearby populations (e.g., Scappoose and Clatskanie) are considered in transition at this time (NMFS 2018a). Reductions were also noted in the number of hatchery-origin juvenile coho salmon released into the Sandy River.

Mass marking of hatchery-released fish, in conjunction with expanded coho salmon spawning surveys, has provided more accurate estimates of hatchery straying. Integrated hatchery programs have been developed in a number of basins to limit the loss of genetic diversity. The integrated program in the Cowlitz River was recently initiated using predominantly natural-origin broodstock. Large-scale releases of hatchery-origin coho salmon adults into the Upper Cowlitz, Cispus, and Tilton Rivers are likely partly responsible for the high numbers of returning nucleolus organizer regions (genetic clusters). An integrated program for Type N coho salmon has been ongoing in the Lewis River for over a decade. Still, the majority of hatchery production is from segregated programs, and few populations met the HSRG (2009) criteria for primary or contributing populations.

2.12.2.8 Recent Ocean and Lower River Harvest

NMFS signed the 2018 to 2027 *U.S. v. Oregon* Management Agreement of the Columbia River Basin. The decision was based on both our recently completed Final EIS and the associated biological opinion (NMFS 2018a). The agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho; ensures fair sharing of harvestable fish between tribal and nontribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*; protects and conserves ESA-listed and unlisted species; and ensures that NMFS fulfills its trust/treaty responsibilities to Columbia River basin tribes. There is no direct commercial fishery for naturally produced LCR coho salmon.

LCR coho salmon are part of the Oregon Production Index and are currently harvested in ocean fisheries, primarily off the coasts of Oregon and Washington. Harvest of this ESU historically occurred off of the west coast of Vancouver Island at substantial rates but has been greatly diminished through reductions renegotiated in Pacific Salmon Treaty Agreements. Canadian coho salmon fisheries were severely restricted in the 1990s to protect upper Fraser River coho salmon and have remained so ever since. Ocean fisheries off California were closed to coho salmon retention in 1993 and have remained closed ever since. Ocean fisheries for coho salmon off of Oregon and Washington were dramatically reduced in 1993 in response to the depressed status of Oregon Coast coho salmon and subsequent listing, and moved to mark-selective fishing beginning in 1999. LCR coho salmon benefitted from the more restrictive management of ocean fisheries. Overall exploitation rates[401] regularly exceeded 80 percent in the 1980s but have remained below 30 percent since 1993. In addition, freshwater fisheries impacts on naturally produced coho salmon have been markedly reduced through the implementation of mark-selective fisheries. The exploitation rate for LCR coho salmon has averaged 13.7 percent since 2008 (JCRMS 2019).

2.12.2.9 Predation

2.12.2.9.1 Avian Predation

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and Columbia River plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including LCR coho salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island, where marine forage fish would be available to diversify the tern diet. Roby et al. (2017) estimated that terns on East Sand Island consumed an average of 5.1 million smolts per year, a 59 percent reduction from when the colony was on Rice Island.

Evans and Payton (2020) estimated predation rates by East Sand Island Caspian terns for LCR coho salmon using a model that adjusts for tag deposition rates as described above for Interior Columbia ESUs/DPSs. Average annual predation rates were 2.6 percent during the pre-management and 3.1 percent during the management periods (Evans and Payton 2020) (Appendix B). The difference was not statistically credible. Another 1,000 terns tried to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers in 2018 and 2019 (Harper and Collis 2018, USACE 2019), further increasing effects on LCR coho salmon compared to the pre-management period.

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on LCR coho salmon in 2003 to 2014 was 2.6 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the

[401] Exploitation rate is the proportion of the total number of fish from a given natural-origin population(s) or hatchery stock(s) that die from the result of fishing activity in a given year.

smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[402] where smolts are likely to constitute a larger proportion of the diet. The average annual predation rates on LCR coho salmon reported by Evans and Payton (2020) for the East Sand Island cormorant colony during the two post-management periods (0.2 percent in 2015 to 2017 and 0.3 percent in 2018) therefore cannot be directly compared to those before management began, and are likely to underestimate predation rates in the estuary.

In the hydrosystem reach, the Action Agencies have employed wire arrays, pyrotechnics, water cannons, and other measures, including limited lethal take at project tailraces in the lower Columbia River. These measures have been shown to reduce predation rates on juvenile salmonids at John Day and The Dalles Dams, and may have had similar effects at Bonneville Dam (Zorich et al. 2012).

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on LCR coho salmon after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts over estimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead; and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different but related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., had no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all

[402] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns (an additive effect). But the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, will also be important.[403]

With respect to management of terns in the estuary, Caspian terns nesting on East Sand Island were eating an average of 2.6 percent of the juvenile LCR coho salmon outmigrants per year before management actions reduced the size of that colony, and 3.1 percent per year thereafter, which is not a statistically credible difference (Evans and Payton 2020). Therefore, there is no evidence that this management measure contributed to increased adult returns for LCR coho salmon, regardless of the likelihood of compensatory effects. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 15.0 percent to less than 1 percent, a large decrease. However, in this case, predation rates on LCR coho salmon are likely to have increased because thousands of birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[404]

2.12.2.9.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one

[403] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

[404] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). On average, four adults and one juvenile coho salmon were killed and/or handled each year in the Sport Reward Fishery during 2015 to 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019).

In addition to the Sport Reward Fishery the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019. Anglers did not catch any coho salmon in 2015 through 2019 (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). During these same years, the Dam Angling Program has removed an average of 2,792 northern pikeminnow from The Dalles Dam tailrace alone, but since the LCR coho salmon ESU only includes populations found below The Dalles Dam, this program is not likely to provide much benefit to juvenile LCR chum salmon.

Juvenile salmonids are also consumed by nonnative fishes, including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these fish, both in the lower Columbia River and Bonneville Reservoir may incrementally improve juvenile coho salmon survival.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile coho salmon, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. In 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP. These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal remains unclear. However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the coho salmon that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a

30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity for LCR coho salmon. As such, it likely continues to benefit the ESU.

2.12.2.9.3 Pinniped Predation

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). California sea lions, Steller sea lions, and harbor seals all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace Bonneville Dam. ODFW counted the number of individual California sea lions hauling out in the Columbia River mouth at the East Mooring Basin in Astoria, Oregon, from 1997 to 2017. Individual pinniped counts at East Mooring Basin have steadily increased since the inception of the observation program with rapid increases within the last decade (Wright 2018). Within the Columbia River, the abundance of pinnipeds peaks in the spring, but has also increased substantially when LCR coho adults are migrating through the estuary.

Adult coho salmon enter the lower Columbia River during late summer and pass Bonneville Dam during August through November (DART 2019b). Moderate numbers of California sea lions are present in the Columbia River estuary and are likely to consume adult coho during their migration. In the last 10 years, a range of 187 to 1,318 California sea lions were counted in Astoria during the months of August and September (Wright 2018). Steller sea lions have been counted in the reach below Bonneville Dam throughout the year, including months when LCR coho salmon are present. The number of predatory Steller sea lions consuming adult coho in the fall at Bonneville Dam has increased considerably in the last 5 years, and pinnipeds were estimated to have consumed 3.1 percent of the adult coho run migrating past Bonneville Dam in 2018 (Tidwell et al. 2019).

Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal, during the spring and summer months. From 2008 to 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). A total of 27 and 19 California sea lions were removed from Bonneville Dam in 2018 and 2019, respectively (Tidwell et al. 2018, 2020). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between RM 112 and McNary Dam (RM 292), or in any tributary to the

Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

2.12.2.10 Research, Monitoring, and Evaluation Activities

The primary effects of the past and present CRS-related RME programs on LCR coho salmon are those associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were LCR coho salmon. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the LCR coho salmon ESU by reducing predation throughout the migration corridor.

For all other CRS-related RME programs, we estimated the number of LCR coho salmon that have been handled (or have died) each year during the implementation of RME as the average annual take reported for 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- Average annual estimates for handling and mortality of LCR coho salmon associated with the Smolt Monitoring Program and the CSS were as follows:
  - 113 natural-origin juveniles were handled, and one natural-origin juvenile died.
- Average annual estimates for LCR coho salmon handling and mortality for all other RME programs were as follows:
  - No hatchery or natural-origin adults were handled.
  - No hatchery or natural-origin adults died.
  - 3,644 hatchery and 9,150 natural-origin juveniles were handled.
  - 13 hatchery and 58 natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) of LCR coho salmon associated with these elements of the RME program will, on average, affect zero percent of the natural-origin adult (recent, 5-year average) run (at the Columbia River mouth) and 1.5 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities which negatively affects LCR coho salmon.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the ESU level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.12.2.11 Critical Habitat

The condition of LCR coho salmon critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized in Table 2.12-3. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for LCR coho salmon production have been weakened. Conditions in the portion of the hydrosystem designated as critical habitat (i.e., the mainstem Columbia River below the confluence of the Hood River) were substantially affected by the development and operations of the CRS run-of-river projects and upstream storage reservoirs. Effects on the migration corridor PBFs include altered mainstem flows, passage delays, injury and mortality, and increased opportunities for predation. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for LCR coho salmon have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.12-3. Physical and biological features (PBFs) of designated critical habitat for LCR coho salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater spawning sites for all populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of spawning sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of spawning sites for all populations. Excessive sediment in spawning gravel (forest and agricultural practices) has reduced the quality of freshwater spawning sites for all populations. Some improvement in riparian, channel, and floodplain conditions in the lower ends of tributaries where large dams have been removed (e.g., White Salmon, Hood, and Sandy Rivers) has improved the quality of freshwater spawning sites for some populations. Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		and agricultural practices) has reduced the quality of freshwater spawning sites for all populations. Many tributary habitat improvement actions implemented in the lower Columbia River basin by Federal, tribal, state, local, and private entities, including the Action Agencies to improve habitat complexity and riparian area condition, reduce fish entrainment, and remove barriers to spawning habitat.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, and natural cover.	Tributary barriers (culverts, dams, water withdrawals) have reduced access to freshwater rearing sites for many populations. Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations. Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) has reduced the quality of freshwater rearing sites for all populations. Excessive sediment in streambeds (forest and agricultural practices) has reduced the quality of freshwater rearing sites for all populations. Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) have reduced water quality in freshwater rearing areas for many populations. Inundation of the lower reaches of tributaries to Bonneville Reservoir has limited the availability of freshwater rearing habitat for two of 24 populations (hydrosystem development). We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is available within the 5-foot operating range.
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover.	Alteration of the seasonal flow regime in the lower Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation).[1] Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderate negative effect in lower flow years for all populations. Alteration of the seasonal mainstem temperature regime in the lower Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		the late summer and fall, when adult coho salmon are migrating, compared to historical conditions (hydrosystem development and operation) has reduced water quality in the migration corridor. Reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (hydrosystem development) may have reduced “natural cover” in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining) affects all populations. The Corps has developed best management practices to minimize accidental releases from oils and greases where hydrosystem projects are in contact with the water, to limit adverse effects in case of an accidental release, and to use “environmentally acceptable lubricants” where feasible. Increased exposure of juveniles to TDG (water quality) in the gorge area and at least 35 miles below Bonneville Dam during involuntary and flexible spring spill (hydrosystem development and operations) has reduced water quality in the migration corridor for juveniles from populations in the Columbia Gorge MPG. The incidence of adverse effects (GBT in juveniles and adults) appears to have been small in recent years (1 to 2 percent). Adult coho salmon are late summer and fall migrants and therefore not exposed to elevated TDG associated with spring spill. Delay and mortality of juveniles and adults from Gorge populations at Bonneville Dam (hydrosystem development and operations) has increased obstructions in the migration corridor for two of 23 populations. However, obstructions have been substantially reduced for juveniles with the construction of surface passage structures and improved bypass systems and by increased spill operations during the spring juvenile outmigration. Small increases in obstructions for adult coho salmon during routine outages associated with scheduled maintenance or non-routine maintenance of fish facilities or turbine units (delay and mortality of adults migrating past Bonneville Dam). Behavioral avoidance of the area during routine dredging or rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. Very small increase in obstructions for juvenile coho salmon because few are present during

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		the December to March work window for routine maintenance activities. Non-routine maintenance typically includes tasks that are more significant than routine scheduled maintenance. Examples of non-routine maintenance include repair of the spillway apron at Bonneville Dam and overhauling the juvenile bypass system. Small increase in obstructions during non-routine, scheduled and unscheduled maintenance of turbine units or other structures (increased risk of fall back for adults and degraded tailrace conditions for juveniles). Small reduction in water quality due to higher TDG levels. The overall effect of unscheduled events on the functioning of the migration corridor is usually reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Concerns about increased opportunities for predators, especially birds and pinnipeds in the tailrace of Bonneville Dam (excessive predation) for Gorge populations. Avian predation is addressed by wire arrays, spike strips, water sprinklers, pyrotechnics, and propane cannons. Pinniped predation is addressed by the use of sea lion excluder devices at the fishway entrances at Bonneville Dam.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, and juvenile and adult forage.	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects), have reduced access to floodplain habitat for rearing and prey production and the quantity and quality of estuarine rearing areas for all populations. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling steelhead by more than 2.5 percent. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation for all populations. Implementation of the Caspian Tern Management Plan on East Sand Island does not appear to be reducing excessive predation on juvenile coho salmon. Implementation of the Double-crested Cormorant Management Plan may have contributed to or at least coincided with the movement of thousands of birds to the Astoria-Megler Bridge. Predation rates for birds foraging from that location are likely to be even higher than for cormorants foraging from East Sand Island.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Observations of increased pinniped predation and risk for adults from all populations.
Nearshore marine areas[2]	Free of obstruction and excessive predation with water quality, quantity, and forage.	Concerns about increased pinniped predation and adequate forage. Reduced quality of nearshore marine areas.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.12.2.12 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of LCR coho salmon, including recent biological opinions issued for LCR coho salmon and key emergent or ongoing habitat concerns (NMFS 2016i). From January 2015 through May 22, 2020, we completed 473 formal consultations that addressed effects to LCR coho salmon.[405] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during

[405] PCTS data query July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPAs were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.12.2.13 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of LCR coho salmon populations. Recent improvements in passage conditions at Bonneville Dam and at tributary barriers, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, and efforts to improve hatchery practices and lower harvest rates are positive signs, but these and other stressors are likely to continue. NMFS (2016c) identified past land development and increasing human population pressures as likely to continue to degrade habitat, especially in lowland areas. These factors, in combination with predation pressure and the potential effects of climate change, continue to negatively affect LCR coho salmon populations.

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for LCR coho salmon. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in the last two decades to improve the functioning of some of these PBFs of critical habitat. For example, passage structures and spill operations have reduced obstructions for juvenile LCR coho salmon at Bonneville Dam. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. However, the factors described above continue to have negative effects on these PBFs.

2.12.3 Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.12.3.1 Effects to Species

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams in an attempt to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns.[406] Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG gas cap spill for a minimum of 16 hours per day, and may operate under "performance standard spill" for up to 8 hours per day. John Day Dam will spill up to120 percent TDG gas cap spill for 16 hours per day, with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs spill constraint) and 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in these periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under the higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.12-4.

[406] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

Table 2.12-4. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.12-5. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.12-5. Proposed summer spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[2]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March; decreased flows from May through August, and little change in flows in April and September) described in the environmental baseline will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse Dam operations are intended to benefit resident species. The change in Libby Dam operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce winter spill events (and associated elevated TDG levels), which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries when TDG is excessive.

This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.12-3).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

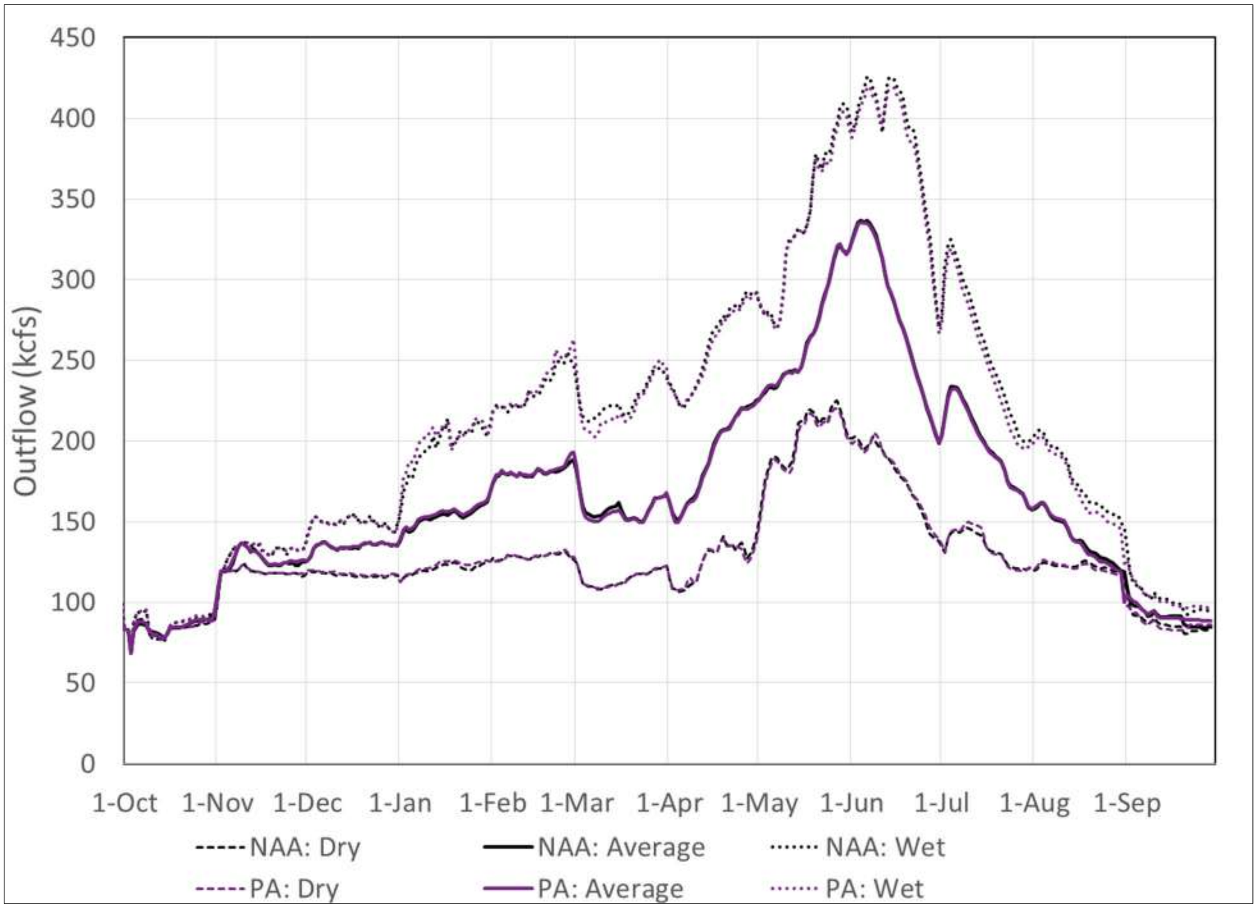

Figure 2.12-3. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

These proposed changes in reservoir operations are not likely to meaningfully affect the probability of meeting spring or summer flow objectives, and associated effects on LCR coho smolts or adults by a meaningful amount.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[407] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges

[407] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Any effects of oil and grease on LCR coho salmon are likely to be very small and are not expected to detectably affect reach survival estimates.

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency hypothetically increases the exposure of LCR coho salmon juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile LCR coho salmon tend to spend less than a month in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

Maintenance of fish ladders, screens, bypass systems, and turbine units will occur along with dredging and rock removal to ensure reliable operation and structural integrity of the fishways at Bonneville Dam. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of juvenile LCR coho salmon present and these effects will occur at extremely low levels similar to what was observed in the recent past. Some late migrating LCR coho salmon adults may be present during maintenance activities and could be handled, delayed, or killed in limited circumstances. Efforts to maintain at least one available fish ladder will continue to allow LCR coho adults to pass. Maintenance activities have been developed through FPOM to avoid impacts and may be modified if evidence indicates elevated delay and mortality are occurring. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative ladders, attraction, or turbine unit priorities) and the efficient return FPP protocol will likely minimize these impacts.

The effects of the proposed hydrosystem operations and the non-operational measures on LCR coho salmon and its habitat are described below.

2.12.3.1.1 Hydrosystem Operation

For LCR coho salmon, the effects of the continued operation of the CRS will generally be consistent with recent operations and mitigation measures, with the addition of the proposed flexible spill operation. This includes continued utilization of recent passage improvements that have increased the survival of juvenile coho salmon that pass through Bonneville Dam (Upper Gorge/White Salmon and Upper Gorge/Hood populations).[408] Though there are no specific data for yearling coho salmon, we estimate that 95 to 97 percent of yearling Chinook salmon that migrate past Bonneville Dam will survive under the proposed operation (BPA et al. 2020); this affects two of the 24 populations of LCR coho salmon. LCR coho salmon smolts migrating through Bonneville Dam are likely to have similar levels of direct survival passing the dam.

During periods of increased spring spill while implementing the flexible spring spill operation, the effects to LCR coho salmon include: 1) juveniles from the two populations upstream of Bonneville Dam will be more likely to pass Bonneville Dam via the spillway than via the juvenile bypass or corner collectors, and 2) exposure of juveniles to increased levels of TDG will increase both within Bonneville Reservoir and downstream of the dam for at least 35 miles. Recent studies indicate that direct survival of steelhead and Chinook salmon smolts passing over the Bonneville spillway was lower than through the Bonneville Powerhouse 2 Bypass or the Bonneville corner collector. Thus, shifting passage from these routes to the spillway may lead to a decrease in direct passage survival on the order of 2 to 3 percent (of the fraction of fish affected). While the CSS predicts increased spillway passage at Bonneville will improve adult returns for Chinook and steelhead (CSS 2017), they make no predictions for LCR coho. The proposed flexible spill operation would likely result in a slight increase in the incidence and

[408] These include improvements to the sluiceway fish guidance system (efficiency and conveyance) and the installation of minimum gap runners at Bonneville PH1; the surface passage route (corner collector), fish guidance efficiency improvements, and the juvenile bypass system at PH2; and the provision of 24-hour spill during the spring migration period through the spillway.

severity of GBT symptoms and a very small increase in mortality for individuals from the Gorge and upper portion of the Cascade MPG.

Since adult coho salmon typically pass Bonneville Dam in September through November, and spring spill at Bonneville ceases on June 15, adult coho will not be affected by factors associated with increased levels of spring spill.

The proposed operations at Libby Dam, Hungry Horse Dam, and Grand Coulee Dam should not affect juvenile migration or survival because the operations would only affect summer flow, which is not when these fish migrate. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

The proposed operations at Libby and Hungry Horse Dams should not have any substantial effect on summer flow. The proposed operation at Grand Coulee Dam will have a very slight effect on flow, primarily in August, and should be too small to affect adult migration or survival. The proposed operation at Dworshak Dam should not affect adults because any potential flow reduction would occur in high flow years during the spring, which is not when these adults migrate.

The Action Agencies propose to reduce summer spill at the eight mainstem dams from August 15 to 31. This change would affect LCR coho salmon that may be migrating during that period in August by improving adult ladder attraction conditions and reducing fallback rates. However, individuals that fell back would experience greater risk because they would be more likely to pass via turbines and juvenile bypass systems instead of the spillway.

Under most conditions, the best operating range for turbines is within ±1 percent peak efficiency range, as it produces the most power for a given volume of water. This range, unless there is project-specific information available, is also generally thought to provide the best passage conditions and survival rates for salmonids passing through the units. Under the proposed action, after required fish passage spill operations have been met, turbines might operate above the 1 percent peak efficiency range under limited conditions and for limited durations, for three reasons: 1) Contingency Reserves, 2) TDG Management, and 3) Balancing Reserves (COE et al. 2020b). This action is a change from past operations when the turbines operated, with few exceptions, within the 1 percent peak efficiency range during the fish passage season.

Operating turbine units above the 1 percent efficiency range resulting from deployment of contingency reserves to meet energy demands caused by unexpected events is expected to occur roughly once per month per project, average about 35 minutes per event, and never last longer than 90 minutes (USACE et al. 2020). These short-duration events could slightly reduce turbine unit survival for adult and juvenile salmonids passing through the turbine units, but the number of LCR coho salmon affected should be extremely low. Operating turbine units above the 1 percent efficiency range during high flow events when spill levels would exceed 125 percent TDG, could reduce TDG exposure and improve ladder attraction conditions for adult LCR coho salmon, but would also slightly reduce turbine unit survival for adult and juvenile salmonids passing through the turbine units, and would also increase powerhouse passage rates for juveniles. These flow levels would be expected to occur in up to 5 to 10 percent of the years at Bonneville Dam; further, increased generation could only occur if load was available, further diminishing the frequency with which this operation could actually occur. Operating turbine units above the 1 percent efficiency resulting from using balancing reserves to follow sub-hourly power demand and supply fluctuations could also slightly reduce turbine unit survival for adult salmonids passing through the turbine units.

Based on analysis of the past 10 years (USACE et al. 2020), the Action Agencies estimate that the average potential number of hours per month that turbine units might exceed the 1 percent peak efficiency range is an average of 8 to 30 hours per project, with a maximum of 8 to 80 hours per project, for lower Columbia River dams, from April through June. Increased flows through the units as a result of these operations should be about 500 cfs or less 95 percent of the time. Again, this modeling was conducted to assess the potential for this operation, and, thus, likely overestimates the duration that would actually be implemented. Overall adult survival rates of LCR coho salmon originating or migrating above Bonneville Dam should not be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range. While there is some evidence that this operation could decrease juvenile survival rates (Skalski et al. 2002) of LCR coho salmon through Bonneville Dam, given the relatively short duration (and magnitude) of the exceedance and the low proportion of juveniles passing through the units under the Flexible Spring Spill Operation, we do not expect that juvenile survival would be measurably reduced at the population, MPG, or ESU level as a result of the proposed turbine unit operations above 1 percent peak efficiency range.

2.12.3.1.2 Predation Management and Monitoring Actions

The Corps' program to install and operate sea-lion excluder gates at Bonneville Dam will continue and is likely to positively affect the two populations that pass upstream of Bonneville Dam. Likewise, the Corps' and BPA's support of increased land-based sea-lion harassment and removal efforts from the area downstream of Bonneville Dam are likely to continue to reduce adult mortality of the two upstream populations.

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. This fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that the numbers of coho salmon, including LCR coho salmon, handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy) will be no more than one adult and 10 juveniles per year, system-wide. The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams, as described in the proposed action (BPA et al. 2020). Since the likelihood of the Dam Angling Program moving to Bonneville Dam in the future is not is not reasonably certain to occur, it is unlikely that the program will have a substantial positive effect on the abundance of any LCR coho salmon populations.

These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of coho salmon, including LCR coho salmon.

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions are likely to continue current levels of predation at these colonies, which, in the case of Caspian terns, does not appear to have reduced predation rates on this ESU. Although there does appear to have been a large decrease in predation rates by double-crested cormorants nesting on East Sand Island (from 15.0 percent before colony management to less than 1 percent), large numbers of these birds have relocated to other sites in the estuary such as the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, cormorant predation in the estuary may be an increasingly important source of mortality for LCR coho salmon.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none have been proposed at this time.

The Action Agencies will also continue to implement, and improve as needed, the avian predation deterrence measures at the tailraces of lower Columbia River dams, which address another source of mortality for juvenile LCR coho salmon emigrating from populations in Bonneville Reservoir. These measures will continue to reduce predation on juvenile coho salmon, although Zorich et al. (2012) were unable to quantify the amount of protection.

2.12.3.1.3 Habitat Actions

For LCR coho salmon populations that have been negatively affected by CRS operations and maintenance, the Action Agencies will provide funding and/or technical assistance for tributary habitat improvement actions consistent with recovery plan implementation priorities and other regional efforts, as funding allows. If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could benefit the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for LCR coho salmon as part of this proposed action, or proposed such actions in a manner that would allow us to meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential actions in our jeopardy analysis.

The Action Agencies will continue to implement the CEERP in the estuary (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to LCR coho salmon as they migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting into the future. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty in predicting the timing and accomplishment of habitat restoration actions and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway. Continued implementation and evaluation of this monitoring program will either confirm that these floodplain reconnections are enhancing conditions for yearling salmonids, such as LCR coho salmon as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during the period covered by this consultation and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during the period of the proposed action, increasing the flux of insects and amphipods to the mainstem migration corridor for LCR coho salmon. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[409] of all LCR coho salmon populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

2.12.3.1.4 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for the impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action will have the same effects as those described generally in the Environmental Baseline section and in detail within the site-specific biological opinions referenced therein (see Section 2.12.2.7). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here.

2.12.3.1.5 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile (and adult) LCR coho salmon are likely to be present in shallow shoreline areas, an unknown portion of the ESU will continue to be stunned, harmed or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this ESU that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The present, 5-year average number of observed juvenile salmonids being stunned and harmed annually by the project is 90,000 per year. Some of this take could result in injury or reduced fitness. These averages will

[409] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile coho salmon opportunities to move into wetland habitats for food and refuge from predators. Moreover, the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the LCR coho salmon ESU.

be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[410]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of LCR coho salmon will be affected each year:

- Activities associated with the Smolt Monitoring Program and the CSS:
    - One hatchery and one natural-origin adult will be handled.
    - One hatchery and one natural-origin adult will die.
    - Zero hatchery and 2,000 natural-origin juveniles will be handled.
    - Zero hatchery and 40 natural-origin juveniles will die.
- Activities associated with all other RME programs:
    - 1,000 hatchery and 600 natural-origin adults will be handled.
    - 10 hatchery and 10 natural-origin adults will die.
    - 20,000 hatchery and 19,000 natural-origin juveniles will be handled.
    - 200 hatchery and 560 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program will, on average, affect 1.9 percent of the natural-origin adult (recent, 5-year average) run (arriving at mouth of the Columbia River) and 3.3 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to much less than 1 percent of estimated ESU abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs

[410] Ongoing and future discussions are expected to lead to substantial reductions in electrofishing sampling by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the small effects of the RME programs on abundance are acceptable and warranted.

2.12.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to result in a small reduction in obstructions at lower Columbia River dams for individuals from two of the 24 LCR coho salmon populations—the Upper Gorge/White Salmon and Lower Gorge/Hood. Adult LCR coho salmon enter the Columbia River during late summer and fall and will not be exposed to elevated TDG resulting from the spring spill program. Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary. Effects of the proposed action on the PBFs are described in Table 2.12-6.

Table 2.12-6. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the LCR coho salmon ESU.

PBF	Effect of the Proposed Action
Freshwater spawning sites	LCR coho salmon spawn in intermediate positions in tributaries, typically further upstream than chum or fall-run Chinook, but often downstream of steelhead or spring-run Chinook. The proposed action therefore is unlikely to affect the functioning of this PBF.
Freshwater rearing sites	Continued inundation of some coho rearing sites in the lower reaches of tributaries to Bonneville Reservoir (reduced availability of freshwater rearing sites for two of 24 populations). We do not know how much habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat will be available within the proposed 5-foot operating range. Continued reduction in quantity of rearing habitat for two populations. See also "estuarine areas."
Freshwater migration corridors	Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. Proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but this will not change the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal temperature regime in the lower Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring when juvenile coho salmon are migrating and warmer temperatures during late summer and fall, when adult coho salmon are migrating. In general, cooler spring temperatures will not adversely affect the functioning of the mainstem as a migration

PBF	Effect of the Proposed Action
	corridor for juveniles. However, this will continue to negatively affect water quality in the adult migration corridor. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (reduction in "natural cover"). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Increased levels of TDG in the gorge area and at least 35 miles downstream of Bonneville Dam during flexible spring spill. The effect on water quality in the juvenile migration corridor in terms of increased incidence of GBT is likely to be small. Adults are fall migrants and will not be exposed to higher TDG levels during the spring spill operation. The Corps will continue to protect water quality by using best management practices to minimize accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. The flexible spring operation to 125 percent TDG will increase obstructions in the adult migration corridor by a small amount for two populations by increasing the risk of fallback over project spillways. Increased spill levels resulting from the flexible spring spill operation (up to 125 percent TDG) are likely to further reduce juvenile travel time by a small amount compared to recent operations, thereby reducing exposure to predators in the The Dalles Dam to Bonneville reach (reduction in excessive predation in the juvenile migration corridor) compared to recent operations for the two populations with spawning areas above Bonneville Dam. Operating turbines above the 1 percent efficiency range to deploy contingency reserves, balance reserves, or during high flow periods is likely to reduce TDG exposure for juveniles and adults (improved water quality) and improve ladder attraction conditions for adults (reduction in obstructions) for the two populations with spawning areas above Bonneville Dam. However, by increasing powerhouse flows, it will increase obstructions for juveniles and adults from these populations by a small amount because some will pass downstream or fall back through a turbine unit. This operation will not affect the functioning of the juvenile and adult migration corridors below the tailrace of Bonneville Dam. Continued small increases in obstructions for adult coho salmon during routine outages of fishways or turbine units at Bonneville Dam. Very small increases in obstructions for juveniles due to degraded tailrace conditions because few will be present during the December to March work window. Continued small increases in obstructions during non-routine maintenance activities. Small reductions in water quality (elevated TDG) due to reduced powerhouse capacity and increased spill during these activities. Non-routine maintenance will be scheduled during the December to March work window when possible to reduce the risk of negative effects. Continued small increases in obstructions during unscheduled maintenance of turbine units or other structures (increased risk of fall back for adults and degraded tailrace conditions for juveniles). Small reductions in water

PBF	Effect of the Proposed Action
	quality due to higher TDG levels. Effects on functioning of the migration corridor will be reduced by prioritizing adjacent units and providing additional attraction to other passage routes. Continued deployment of sea-lion exclusion devices and hazing at Bonneville Dam to maintain the protection of adult coho salmon that reach the fishways at current levels (ongoing reduction in predation). Continued implementation of the NPMP to maintain fish predation (ongoing reduction in predation) at current levels. Continued implementation of the avian predation deterrence operations to maintain predation on juvenile coho salmon in project tailraces at current levels (ongoing reduction in levels of predation).
Estuarine areas	Continued improvement in access to floodplain habitat for rearing and prey production with ongoing implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels and juvenile and adult forage). This will increase access to prey for yearling coho salmon that remain in the mainstem. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.12.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.12.1), Environmental Baseline (Section 2.12.2), and Effects of the Action (Section 2.12.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including LCR coho salmon.

NMFS has also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of the activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices that negatively affect water quality and habitat quality. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area including LCR coho salmon.

2.12.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.12.5.1 Species

The LCR coho salmon ESU includes naturally spawned coho salmon originating from the Columbia River and its tributaries downstream from the White Salmon and Hood Rivers (inclusive) and any such fish originating from the Willamette River and its tributaries below Willamette Falls. The ESU contains 24 independent populations in three ecological regions: Coast (seven populations), Cascade (14 populations), and Gorge (three populations); each of these three ecological regions is considered an MPG. Some positive trends in LCR coho salmon status have occurred, although these observations may be based on improved monitoring data (NWFSC 2015). However, abundances are still at low levels and the overall extinction risk rating for 22 populations is high or very high, with only two populations rated as moderate. Compared to earlier estimates, the most recent estimates of population abundance (2014 to 2018 geomeans) indicate no clear trends, with most populations staying at similar levels, but some increasing or decreasing. Recent poor ocean conditions associated with a marine heatwave and its lingering effects have likely contributed to lower than average ocean survival rates for some populations in recent years. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants. For most populations, the proportion of hatchery-origin fish naturally spawning in the ESU exceeds recovery criteria and is a key factor limiting recovery. With recent dam removals on tributaries and the integration of trap-and-haul programs, there are few major spatial structure limitations; however, small migrational barriers such as culverts limit spatial structure.

Two Columbia Gorge populations of LCR coho salmon are affected by upstream and downstream passage at Bonneville Dam. Both have a very high overall risk rating, as do 19 (out of 22) other populations in the ESU. This indicates that the impacts (somewhat lower juvenile and adult survival rates) associated with passage through Bonneville Dam are likely not the most important factor affecting the VSP status of these populations. The removal of Powerdale Dam (Hood River) and Condit Dam (Upper Gorge) should continue to improve VSP ratings for these populations.

Structural and operational improvements at Bonneville Dam should improve passage conditions for juvenile LCR coho salmon from the two populations that spawn upstream of Bonneville Dam. The proposed 125 percent TDG spring spill operation should further increase spill levels at Bonneville Dam (limited to 150 kcfs), which will increase juvenile exposure to TDG beginning April 10. Other operations (e.g., upper Columbia River operations to better protect resident species, Dworshak Dam winter operations to reduce TDG in the lower Clearwater River, operating turbine units above 1 percent peak efficiency for limited amounts of time for power management or TDG management purposes, etc.) could, collectively, have a small, negative effect, especially on juvenile migrants. However, these effects should not measurably alter juvenile survival rates, and overall juvenile passage survival should be maintained or should increase slightly as a result of this proposed operation.

Maintenance of fish ladders, screens, bypass systems, and turbine units will occur along with dredging and rock removal to ensure reliable operation and structural integrity of the fishways at

Bonneville Dam. With maintenance activities occurring within the typical in-water work schedule as described in the baseline (generally December to March), we expect there will be few, or relatively low numbers of juvenile LCR coho salmon present and these effects will occur at extremely low levels similar to what was observed in the recent past. Some late migrating LCR coho salmon adults may be present during maintenance activities and could be handled, delayed, or killed in limited circumstances. Efforts to maintain at least one available fish ladder will continue to allow LCR coho adults to pass. Maintenance activities have been developed through FPOM to avoid impacts and may be modified if evidence indicates elevated delay and mortality are occurring. The effects of non-routine and unscheduled maintenance may delay or kill some juveniles and adults but alternative measures as coordinated in FPOM (e.g., alternative ladders, attraction, or turbine unit priorities) and the efficient return FPP protocol will likely minimize these impacts.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing condition. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving LCR coho salmon abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this ESU. However, other factors (e.g., ocean conditions) also strongly influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan and the Double-crested Cormorant Management Plan, as well as hazing at Bonneville Dam. Based on the data in Evans et al. (2020), management of the East Sand Island tern colony has not reduced tern predation on LCR coho salmon. Cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that likely prey on juvenile LCR coho salmon are also present in the hydrosystem reach. The NPMP is expected to continue providing similar benefits of predator removal (northern pikeminnow). Together, these programs will maintain current levels of predation. In the case of the NPMP, it is creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if this action was not taken.

Pinniped predation on LCR coho salmon in the lower Columbia River and estuary has increased with recent increases in the abundance of sea lions. Pinniped abundance has increased in the fall at Bonneville Dam, and the estimated pinniped consumption of coho salmon (all stocks) was about 3 percent in 2018. Sea lion predation downstream of Bonneville Dam, including the estuary, continues to negatively affect the productivity and abundance of LCR coho salmon.

The management of LCR coho salmon hatchery programs has improved compared to historical operations. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to substantially limit the diversity and productivity of natural populations of LCR coho.

Harvest rates on LCR coho salmon in fisheries have decreased substantially compared to historical levels. However, harvest rates remain substantial: the estimated impacts of ocean fisheries are less than 30 percent and the estimated impacts of freshwater fisheries have averaged about 14 percent since 2008.

As described in Section 2.12.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area considered for LCR coho salmon are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect LCR coho salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of LCR coho salmon as high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change.

Adults migrating in the fall could potentially respond temporally to changing environmental conditions by migrating and spawning later in time. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or flood events). Juvenile emergence and rearing could potentially become "out-of-sync" with nursery conditions in streams. Yearling migrants will be negatively affected because they would be exposed to higher summer temperatures. Though the quality of information is mixed, sensitivity in the marine stage is likely high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur. These climate change consequences are not caused by the proposed action. In simple terms, even if the adult abundance declines as predicted under climate change, which will make recovery of this ESU more challenging, it will have declined no more so as a result of the proposed action.

The proposed action includes conservation measures to mitigate the potential adverse effects of the action, in many cases by addressing limiting factors for survival and recovery. These measures include estuary habitat improvement and predator management actions that should benefit VSP parameters, thus reducing the expected abundance declines caused by climate change. Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this DPS (e.g., dam passage survival, population productivity, degraded estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.)

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action directly influences freshwater survival and productivity, especially for those populations upstream of Bonneville Dam. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., estuary habitat, predation, etc.). For the two Columbia Gorge populations, Evidence suggests that these actions have contributed to improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. The proposed action carries forward structural and operational improvements at Bonneville Dam since 2008 and improves upon them and ecosystem functions should continue to increase in estuary habitats where improvement actions occur.

Climate change is a substantial threat to LCR coho salmon, especially during the marine rearing phase of their life cycle. The proposed action should not exacerbate either the scope and/or severity of those impacts.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of LCR coho salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of LCR coho salmon.

2.12.5.2 Critical Habitat

Critical habitat for LCR coho salmon encompasses 10 subbasins in Oregon and Washington containing 55 watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2013a, 2016h) and most of these watersheds have some, or a high, potential for improvement. The removal of some large tributary dams has improved habitat quality in spawning and rearing areas in the middle reaches of these streams used by LCR coho salmon populations. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change, with predicted rising temperatures and alterations in stream flow patterns.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected the conservation of critical habitat in the juvenile and adult migration corridors for LCR coho salmon. Some of these past effects will continue: alteration of the seasonal flow regime (water quantity), reduced sediment discharge and turbidity during spring (water quality), and for three populations with spawning areas above Bonneville Dam, longer travel times and passage delays (obstructions in the migration corridor). These factors have increased the likelihood of excessive predation on some juvenile and adult LCR coho salmon and affected the arrival time of juveniles in the ocean. The latter may have resulted in a mis-match with prey availability, depending on conditions in the nearshore environment.

The CRS also will continue to inundate spawning and rearing habitat (substrate) in the lower reaches of the tributaries to Bonneville Reservoir for the two populations with spawning areas in the Columbia gorge. We do not know how much spawning habitat was inundated when the dam was constructed and the reservoir was filled, but none or very little of this habitat is likely to be available within the 5-foot operating range.

The Action Agencies have reduced effects of their operations on travel time and survival for juveniles for juveniles from the two Columbia Gorge populations by increasing the level of spring spill at Bonneville Dam. We expect the flexible spring spill to 125 percent TDG to further reduce the effect of Bonneville Dam as an obstruction by a small amount. Any additional effect on water quality in terms of the risk of GBT for juvenile and adult coho salmon is likely to be small. Higher spill levels will increase obstructions for adults by a small amount due to the increased risk of fallback over the spillway.

The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors for this species. Operating the turbine units at Bonneville and The Dalles Dams above the 1 percent efficiency range to deploy or balance contingency reserves or during high flow periods is likely to improve water quality through reduced TDG exposure for juveniles and adults and improve ladder attraction for adults from the two Gorge populations (reduced obstructions). However, by increasing powerhouse flows, it will increase obstructions by a small amount because some adults will fall back and juveniles will move downstream through turbines. This operation will not affect the functioning of the juvenile and adult migration corridors below the tailrace of Bonneville Dam. The thermal inertia created by the CRS reservoirs will continue to negatively affect temperatures (water quality) in the adult migration corridor.

The Action Agencies propose to continue to maintain the 14 CRS projects and associated fish facilities, spillway components, navigation locks, generating units, and supporting systems. Scheduled maintenance activities are expected to continue to have short-term, small negative effects on the functioning of the migration corridor in the form of increased obstructions and reduced water quality during the December to March work window. Non-routine and unscheduled maintenance are also likely to increase obstructions and reduce water quality, especially if these events occur during the spring outmigration period. These events will be coordinated through the inseason adaptive management process and measures will be taken, when possible, to reduce negative effects on the functioning of the adult and juvenile migration corridors. In summary, the proposed action is not likely to further limit water quantity or water quality or to increase obstructions in the juvenile migration corridor by a meaningful amount.

The Action Agencies will continue to implement pinniped control measures to reduce predation in the tailraces of Bonneville and The Dalles Dams, the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the lower Columbia River, and the predation management programs for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will maintain the levels of predation in the migration corridors that were observed in recent years, although cormorant predation rates may further increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the estuary, many of these funded through the CRS program. The Action Agencies propose to continue to reconnect an average of 300 acres of the historical floodplain per year, increasing access to rearing areas used by subyearling Chinook salmon and the availability of wetland-derived prey to yearlings migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of LCR coho salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of LCR coho salmon designated critical habitat.

2.12.6 Conclusion

After reviewing and analyzing the current status of LCR coho salmon and its critical habitat, the environmental baseline, the direct and indirect effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR coho salmon or destroy or adversely modify its designated critical habitat.

2.13 Upper Willamette River (UWR) Chinook Salmon

This section applies the analytical framework described in Section 2.1 to the UWR Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the UWR Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.13.1 Rangewide Status of the Species and Critical Habitat

The status of the UWR Chinook salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.13.1.1 Status of the Species

2.13.1.1.1 Background

On March 24, 1999, NMFS listed the UWR Chinook salmon ESU as threatened (64 FR 14308). That status was affirmed on June 28, 2005 (70 FR 37160) and updated on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that this ESU should retain its threatened status (81 FR 33468). Critical habitat was designated on September 2, 2005 (70 FR 52630). The summary that follows describes the status of UWR Chinook salmon. More information can be found in the recovery plan (ODFW and NMFS 2011) and the most recent status review (NMFS 2016e).[411]

[411] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

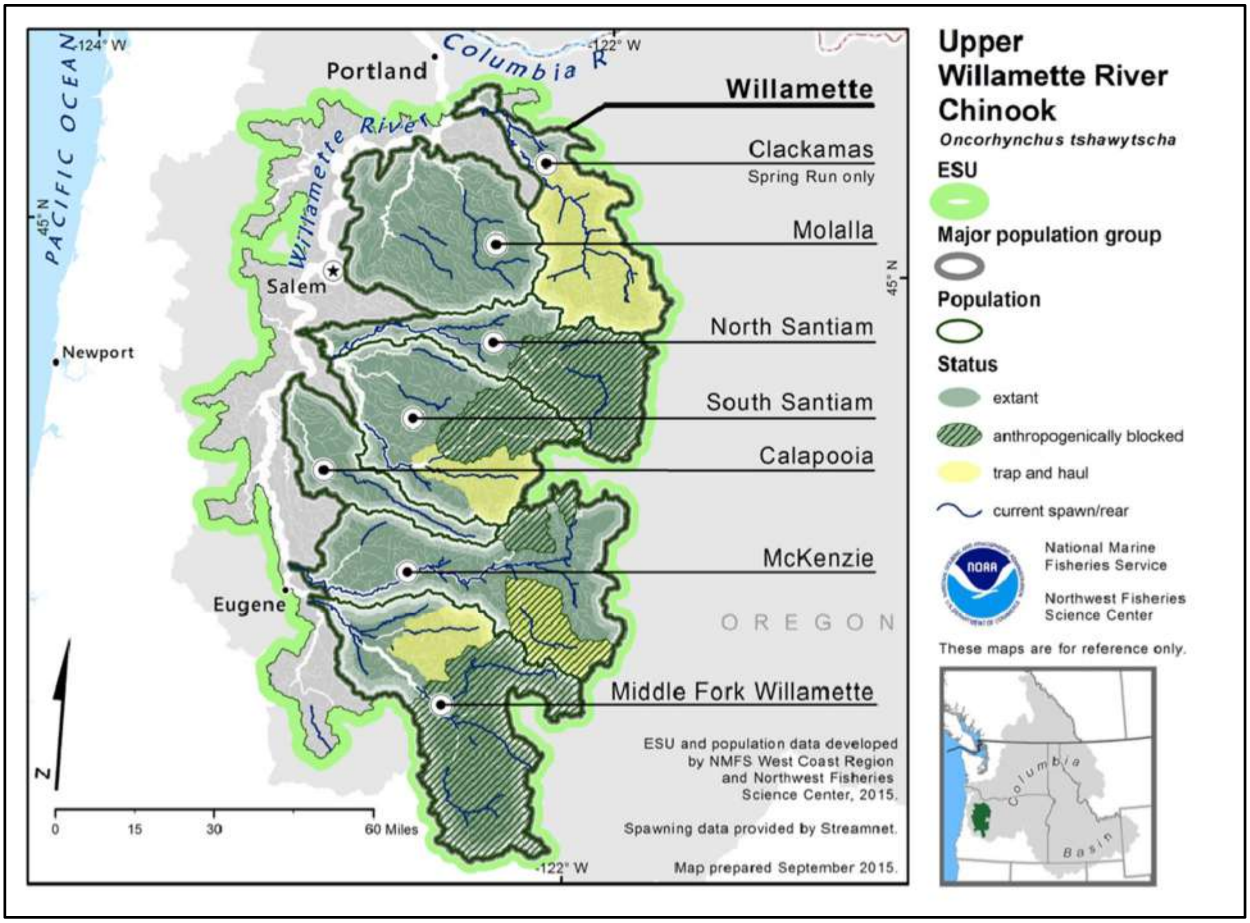

Figure 2.13-1. Map of the UWR Chinook salmon ESU's spawning and rearing areas, illustrating populations and major population groups. Source: NWFSC 2015.

The UWR Chinook salmon ESU includes all naturally spawned spring-run Chinook salmon originating from the Clackamas River subbasin and from the Willamette River subbasins upstream of Willamette Falls, as well as six artificial propagation programs (70 FR 37160).[412] The ESU contains seven independent populations within one MPG (Figure 2.13-1).

2.13.1.1.2 Life-History and Factors for Decline

UWR Chinook salmon differ from other Columbia River basin Chinook salmon according to both genetic and life-history data (Schreck et al. 1986, Utter et al. 1989, Waples et al. 1993, Myers et al. 1998). Recent research has shown that the ESU exhibits several different life-history pathways. Many juveniles from spring Chinook salmon populations reach the Willamette mainstem migration corridor as yearlings, but some juveniles found in the lower Willamette

[412] McKenzie River Hatchery Program (ODFW Stock #23); Marion Forks Hatchery/North Fork Santiam River Program (ODFW Stock #21); South Santiam Hatchery Program (ODFW Stock #24) in the South Fork Santiam River and Molalla River; Willamette Hatchery Program (ODFW Stock #22); and the Clackamas Hatchery Program (ODFW Stock #19). In 2016, NMFS published proposed revisions to hatchery programs included as part of ESA-listed Pacific salmon and steelhead species (81 FR 72759). No changes were proposed for the UWR Chinook salmon ESU. We expect to publish the final revisions in 2020. For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005c).

River are subyearlings (Friesen et al. 2004). These early subyearling migrants can enter the Willamette mainstem (as fry) as early as May and head to the lower Columbia as early as June (Schroeder et al. 2005). Early subyearling migrants have been captured in the upper estuarine zone of the lower Columbia River, and have also been captured in nearshore ocean samples in June. Fall subyearling migrants usually remain in the Willamette subbasins through their first spring and summer; some spend their first winter in the Willamette River, while others move past Willamette Falls on the lower Willamette River before winter, and likely rear in the Columbia River or estuary before entering the ocean as early as March. Adult UWR Chinook salmon enter the Willamette River in January through April and ascend Willamette Falls in April through August (ODFW and NMFS 2011, Rose 2015)

By the time of listing, the UWR Chinook salmon ESU likely numbered less than 10,000 fish, compared to a historical abundance estimate of 300,000 (Myers et al. 2003), and significant natural production occurred only in the Clackamas and McKenzie populations (McElhany et al. 2007). Factors contributing to the decline of the ESU included early fishery exploitation (beginning in the late 19th century) and dramatic declines in water quality and extensive dredging in the lower Willamette River (ODFW and NMFS 2011). Concerns cited by NMFS at the time of listing included: 1) the introduction of fall-run Chinook salmon into the basin, 2) prolonged and extensive spring Chinook hatchery production in the basin, and high proportions of returning hatchery-origin adults, 3) habitat blockage and degradation, including habitat blocked by construction of the Willamette Project dams in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette River Basins and degradation caused by agricultural development and urbanization, and 4) the impacts of high harvest rates (ODFW and NMFS 2011; 63 FR 11482).

2.13.1.1.3 Recovery Plan

The ESA recovery plan for UWR Chinook salmon (ODFW and NMFS 2011) includes delisting criteria for the ESU, along with identification of factors currently limiting its recovery, and management actions necessary for recovery. The biological delisting criteria are based on recommendations by the W/LC TRT.[413] They are hierarchical in nature, with ESU-level criteria based on the status of natural-origin UWR Chinook salmon assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the ESU will require sufficient improvement in its abundance, productivity, spatial structure, and diversity.

2.13.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

NMFS evaluates species status by evaluating the status of the independent populations within an ESU based on parameters of abundance, productivity, spatial structure, and diversity (these

[413] The recovery plan also includes "threats criteria" for each of the listing factors in ESA section 4(a)(1) to help ensure that underlying causes of decline have been addressed and mitigated before considering the species for delisting.

parameters are referred to as the viable salmonid population—or VSP—parameters). Individual population status is considered within the context of delisting criteria, established in recovery plans and based on recommendations of the W/LC TRT. Delisting criteria define parameters for individual population status, as well as for how many and which populations must achieve a particular status for each MPG to be considered at low extinction risk. The Conservation and Recovery Plan for Upper Willamette Chinook salmon and steelhead (ODFW and NMFS 2011) describes the viability criteria in detail, and the parameter values needed for persistence of individual populations and recovery of the ESU.

At the time of the most recent status review (NMFS 2016e), NMFS found that while a few populations had experienced slight improvements in status, others had declined, and overall there had likely been a decline in the status of the ESU. The Clackamas and McKenzie River populations, previously viewed as strongholds within the ESU, had experienced declines in abundance. The apparent decline in the status of the McKenzie River population was a particular concern. In contrast to most of the other populations in this ESU, McKenzie River Chinook salmon have access to much of their historical spawning habitat, although access to historically high-quality habitat above Cougar Dam (on the South Fork McKenzie River) is still limited by poor downstream juvenile passage. Additionally, the installation of a temperature control structure in Cougar Dam in 2008 was thought to benefit downstream spawning and rearing success (NWFSC 2015, NMFS 2016e).

The most recent status review (NWFSC 2015, NMFS 2016e) noted that the Calapooia River population may have been functionally extinct, and that the Molalla River population remained at critically low abundance. The South Santiam River population had also declined in abundance since the previous status review. Abundance in the North Santiam River population had risen since the previous review, but still ranged only in the high hundreds of fish. Improvement in the status of the Middle Fork Willamette River population related solely to the return of natural adults to Fall Creek; however, the capacity of the Fall Creek basin alone would be insufficient to achieve the recovery goals for the Middle Fork Willamette River population (NWFSC 2015).

In terms of spatial structure, the most recent status review noted that access to historical spawning and rearing areas remained restricted by large dams in the four populations that were historically the most productive, and thus spawning and rearing was confined in these populations to more lowland reaches where land development, water temperatures, and water quality may be limiting. Pre-spawning mortality levels were generally high in the lower tributary reaches, where water temperatures and fish densities are generally the highest. Areas immediately downstream of high-head dams may also be subject to high levels of TDG. Hatchery production had remained relatively stable since earlier status reviews, although a number of operational changes had been made at hatcheries that could reduce hatchery impacts eventually (NWFSC 2015, NMFS 2016e).

Given the prospect of long-term climate change, the most recent status review noted that the inability of many populations to access historical headwater spawning and rearing areas may put this ESU at greater risk (NWFSC 2015, NMFS 2016e).

2.13.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the UWR Chinook salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. The recovery plan for UWR Chinook salmon (ODFW and NMFS 2011) identifies key and secondary limiting factors and threats for each population by area and life stage. These include:

- Restricted access to historical spawning and rearing habitat by the Willamette Project flood control/hydropower dams. Willamette Project dams block or delay adult fish passage to major portions of the historical holding and spawning habitat for UWR Chinook salmon in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins. In addition, most Willamette Project dams have limited facilities or operational provisions for safely passing juvenile Chinook salmon downstream of the facilities. In the absence of effective passage programs, UWR Chinook salmon will continue to be confined to lowland reaches, where land development, water temperatures, and water quality are limiting, and where pre-spawning mortality levels are generally high (NMFS 2016e). In addition to the Federal Willamette Project dams, several municipal hydropower or flood control facilities in tributaries also cause adverse effects.
- Hydropower-related limiting factors extend to the Columbia River estuary, where adverse effects on estuarine habitat quality and quantity are related to the cumulative effects of Columbia River basin dams. Effects include an altered seasonal flow regime and Columbia River plume due to flow management (ODFW and NMFS 2011).
- Land use practices including agriculture, timber harvest, mining and grazing activities, diking, damming, development of transportation, and urbanization, which have reduced access to historically productive habitats and reduced the quality of remaining habitat by weakening important watershed processes and functions (ODFW and NMFS 2011).
- Predation by birds, native and non-native fish, and marine mammals, including increasing marine mammal predation at Willamette Falls (NMFS 2016e).
- High proportions of hatchery spawners, although recent improvements offer the potential for collecting more hatchery origin adults and removing them from the natural-spawning component of the North and South Santiam populations (NMFS 2016e).
- Harvest, although overall harvest rates on UWR spring Chinook have dropped from the 50-60 percent range in the 1980s and early 1990s to around 30 percent since 2000 (NMFS 2016e).
- Climate change effects, including increased stream temperatures, changes in precipitation/streamflow, and years of low ocean productivity (NMFS 2016e).

2.13.1.1.6 Information on Status of the Species since the 2016 Status Review

Abundance data for UWR Chinook salmon are available from counts at the Willamette Falls fishway. In 2015, there was a relatively large run of UWR Chinook salmon, with 51,046 total adults (9,954 natural-origin adults) counted at Willamette Falls. However, the most recent 5-year geometric mean for returning adults at Willamette Falls (2015 to 2019) indicates a decline in both natural-origin and total numbers of adults from the previous 5-year geometric mean, for 2010 to 2014 (Table 2.13-1).

Table 2.13-1. UWR Chinook salmon adult abundance at Willamette Falls. The 5-year geometric mean of Willamette Falls counts from 2010 to 2014 was calculated at the time of the most recent status review (NMFS 2016e). The geomean for 2015 to 2019 is based on data reported in NMFS (2019g) and in the ODFW Willamette Falls Fish Counts database (ODFW 2020).

5-Year Geometric Mean	Natural-Origin Adults	Total Adults
2010-2014	9,269	38,630
2015-2019	6,690	30,081

NMFS will evaluate the implications for viability risk of these more recent returns, and additional data at the population level, in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population productivity, diversity, and spatial structure, as well as the updated estimates of abundance shown in Table 2.13-1.

Since 2016, observations of coastal ocean conditions indicate that recent outmigrant year classes have experienced below-average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict the drop in adult Chinook salmon returns observed through 2019 (Werner et al. 2017). Some of the negative impacts on juvenile salmonids had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 50-m surface layer) had not returned to normal (Harvey et al. 2019). Expectations for marine survival are relatively mixed for juveniles that reached the ocean in 2019 (Zabel et al. 2020), suggesting that adult returns could increase somewhat in 2021. However, continued low jack returns as of June 1, 2020, suggest that adult numbers could remain low in 2021.

2.13.1.2 Status of Critical Habitat

NMFS (2005b) designated critical habitat for UWR Chinook salmon to include all estuarine areas and river reaches from the mouth of the Columbia River upstream to the confluence of the Willamette River (50 CFR 226.212(i)). Critical habitat for UWR Chinook salmon encompasses 45 occupied HUC5[414] watersheds in Oregon, as well as the lower Columbia River migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, NMFS 2016e) and have some, or high, potential for improvement. Similar to the discussion above regarding effects on the species, the status of critical habitat is likely to be

[414] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country. A HUC5 is a five-unit (5 two-digit numbers) code. Examples are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the Wenatchee Basin, Washington.

affected by climate change, with predicted rising temperatures and alterations in stream flow patterns. Improved access to spawning and rearing habitat, and habitat restoration efforts, will help reduce those effects on critical habitat.

Of 45 designated HUC5 watersheds within the range of this ESU, NMFS (2005b) gave 23 a high rating, 14 a medium rating, and eight a low rating for their value to the conservation (i.e., recovery) of the species. The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b), as described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.

- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.
- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case of freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Critical habitat also has been designated for UWR Chinook salmon in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. NMFS considers the estuary to have a high conservation value because it connects every population with the ocean and is used by rearing and migrating juveniles and by migrating adults

Human activities since the late 1800s have altered the form and function of the Columbia River estuary, reducing the quantity and quality of its PBFs. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained this environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in the mainstem navigation channel; and causeways have been constructed that restrict the position of tributary confluences.

In addition, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban use. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from upstream reservoirs have changed the seasonal pattern and volume of discharge.

The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of established flow variations in the Columbia River estuary through flow regulation may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has eliminated shallow-water habitats, which were seasonally important rearing areas and refugia for juvenile salmonids, particularly for small subyearling migrants such as some UWR Chinook salmon. Disconnecting the tidal river from its floodplain also prevented delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The rest of the designated areas are within the Willamette River basin, where land management activities have severely degraded stream habitat conditions in the mainstem and associated subbasins above Willamette Falls. In these areas, high density urban development and widespread agriculture have altered watershed processes, reducing aquatic and riparian habitat quality and complexity. The Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging, and other activities that have reduced rearing habitat by as much as 75 percent. In addition, the construction of 37 dams in the basin has blocked access to more than 435 miles of historical stream and river spawning habitat. Storage operations at high-head dams alter the temperature regime of the Willamette River and its tributaries, affecting the timing and development of naturally spawned eggs and fry in downstream reaches. Logging in the Cascade and Coast Ranges, and agriculture, urbanization, and gravel mining on valley floors, have contributed to increased erosion and sediment loads.

The effect of these changes as a whole is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs and thus the conservation value of critical habitat for UWR Chinook salmon within the action area are discussed in more detail in the Environmental Baseline section, below.

2.13.1.3 Climate Change Implications for UWR Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of UWR Chinook salmon and aquatic habitat is climate change. The USGCRP[415] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer

[415] http://www.globalchange.gov

(Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[416] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

Likely changes in temperature, precipitation, and wind patterns (as well as sea-level rise in the lower estuary) have implications for survival and recovery of UWR Chinook salmon in both their freshwater, estuarine, and marine habitats and the PBFs of their critical habitat. While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (ISAB 2007). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1 to 4 feet of global sea-level rise by the end of the century. This sea-level rise and storm surge pose a risk to infrastructure, and coastal wetlands and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

Climate change would affect UWR Chinook salmon and critical habitat in the following ways: 1) warmer stream temperatures could increase pre-spawning mortality and cause changes in growth, development rates, and disease resistance, 2) changes in flow regimes (larger winter floods and lower flows in the summer and fall) could reduce overwintering habitat for juveniles, reduce egg and juvenile survival, reduce spawning habitat access/availability, and alter spawning run timing, 3) timing of smolt migration may change due to a modified timing of the spring freshet, 4) changing ocean conditions and marine food webs could affect ocean survival and growth, and 5) predicted sea-level rise could cause significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007).

[416] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

Crozier et al. (2019) assessed UWR Chinook salmon as having a very high vulnerability to the effects of climate change based on an analysis of the ESU's sensitivity (very high) and exposure (high). Further, the species was determined to have a moderate adaptive capacity. A moderate score for adaptive capacity reflected the conclusion that although UWR Chinook salmon exhibit a remarkable ability to survive in such a highly altered system, it is unclear whether the ESU has further adaptive capacity, given its elevated extrinsic pressures and depressed natural production.[417]

Modified environments available to Chinook salmon in the Willamette River have exerted powerful selection pressures, such that the ESU itself may be fundamentally transforming. For example, in Green Peter Reservoir, individuals have been collected that appear to have completed their entire life cycle in fresh water as the offspring of adfluvial parents rather than as hatchery releases (Romer and Monzyk 2014). Use of reservoirs may be under-reported, as are other juvenile life-history patterns (Bourret et al. 2014). However, the extent to which alternate rearing patterns represent either a viable strategy or an ecological trap is unknown (Bourret et al. 2014). Nonetheless, actions to modify reservoir operations to benefit juvenile production are being considered (Johnson and Friesen 2014), despite uncertain outcomes.

Exposure attributes for UWR Chinook salmon were ranked high overall, due to very high scores for ocean acidification and stream temperature. Mean August temperature was projected to increase 2.5°F by the 2040s, and 4.3°F by the 2080s. Other high exposure attributes included sea surface temperature and hydrologic regime shift. Although approximately 90 percent of the basin is already rain-dominated, the remaining 10 percent is very likely to change to rain-dominated by the 2040s. Scores for ocean acidification and sea surface temperature were similar to those of most ESUs.

Sensitivity attributes for this ESU were ranked very high due to a host of factors, including vulnerability in the adult freshwater stage and cumulative threats to the species' entire life cycle and to its life-history diversity.

2.13.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or

[417] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results.

designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For UWR Chinook salmon, we focus the description of the environmental baseline on the portion of the action area where UWR Chinook salmon juveniles and adults would be most exposed to the effects of the proposed action. Most juvenile and adult UWR Chinook salmon migrate between spawning and rearing habitat in the Willamette River basin directly to the ocean via the lower Columbia River. To determine the upstream extent of UWR Chinook salmon distribution and thus exposure to effects of the proposed action, we reviewed UWR Chinook salmon PIT detections at Bonneville, The Dalles, and McNary Dams from 2013 through 2019. A total of three adults from this ESU were detected at Bonneville Dam during this time, two in 2017 and one in 2016 (Columbia River DART 2019a), i.e., less than one adult per year. Only a single detection was observed at The Dalles and McNary Dams (2017). Therefore, the area where UWR Chinook salmon experience the effects of the proposed action is the Columbia River from the tailrace of Bonneville Dam to the plume,[418] including tributary confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions. It is likely that the small number of adults that ascend Bonneville or other upstream dams fall back, through either the turbines or the spillbays or sluiceway (safer routes), to find their natal tributaries.

2.13.2.1 Mainstem Habitat

On the mainstem of the Columbia River, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

[418] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.13-2). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

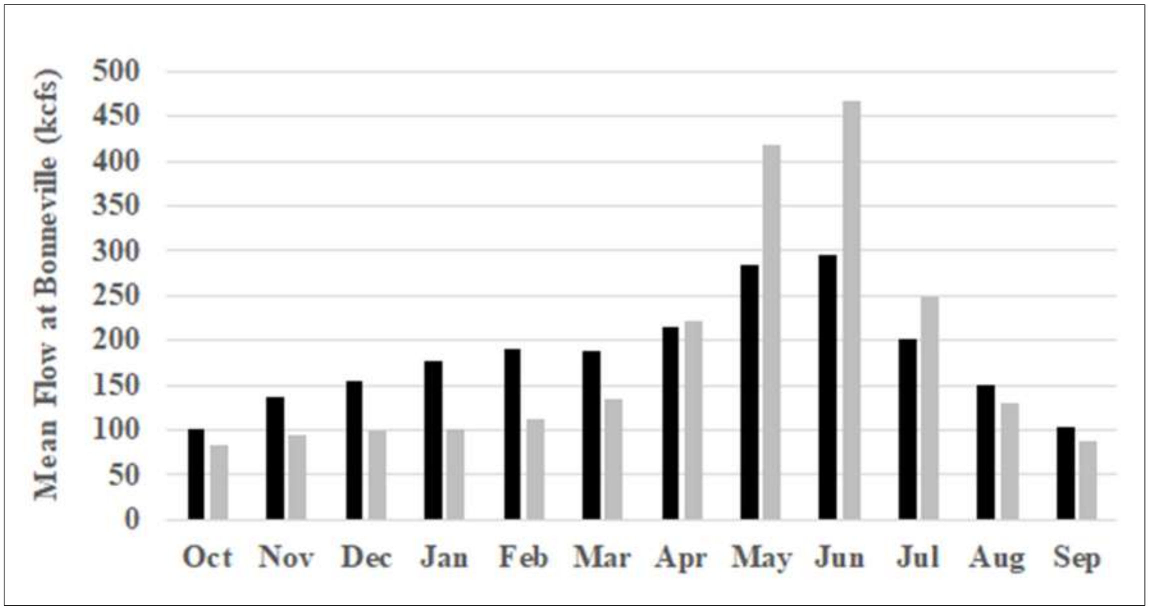

Figure 2.13-2. Simulated mean monthly flows for the Columbia River at Bonneville Dam under “current” (black) and “unregulated” (gray) conditions. “Current” flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. “Unregulated” flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[419] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the

[419] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile salmonids and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.13.2.2 Passage Survival

With the exception of an extremely limited number of adult strays detected at Bonneville Dam (three adults in a recent 10-year period), none of the populations in this ESU pass any of the mainstem CRS projects. We assume that the few adults that pass Bonneville Dam were lost from their spawning populations, but this is unlikely to have affected abundance or productivity at the population level.

2.13.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread

presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult UWR Chinook salmon is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of UWR Chinook salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead survival is a concern; because of temperature standard exceedances, portions of the lower Columbia River are on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.

- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges such as cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

2.13.2.4 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of UWR Chinook salmon in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify, and even more difficult to detect downstream, near and below the confluence of the Willamette River where most UWR Chinook salmon would be exposed. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[420] with enhanced inspection protocols and prepares annual oil accountability reports that record

[420] The Lower Columbia River and Lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[421] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials).

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[421] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river

The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.13.2.5 Tributary Habitat

Information about the species' status in the tributary portion of its life cycle and the status of its critical habitat can be found in Section 2.13.1. Tributary habitat occupied by UWR Chinook salmon is not exposed to the effects of the proposed action.

2.13.2.6 Estuary Habitat

The Columbia River estuary provides important migratory and rearing habitat for UWR Chinook salmon populations. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the estuary have been lost to diking, filling, and bank hardening, combined with hydrosystem flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for subyearling Chinook salmon and reduced the production of wetland macrodetritus that supports salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both for smaller juveniles in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

This ESU produces both yearling and subyearling emigrants (Rose 2015). Some juveniles grow quickly in the lower reaches of their spawning tributaries and the mainstem Willamette River and migrate to the estuary as subyearlings. These fish have been captured in shallow-water habitats along the floodplain and within mainstem islands in the lower Columbia River, with some residing over winter (Johnson et al. 2015).

Subyearling UWR Chinook salmon spend a significant amount of time in the estuary (Hanson et al. 2015, Johnson et al. 2015, Rose 2015; Kidd et al. 2018, 2019). Restoration actions in the estuary such as those highlighted in the most recent 5-year review (NMFS 2016e) have improved connectivity with and prey flux from the floodplain to the mainstem (PNNL and NMFS 2018, 2020). From 2007 through 2019, restoration sponsors implemented 64 projects, including dike and levee breaching or lowering, tide gate removal, and tide gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents a more than a 2.5 percent net increase in a connectivity index for habitats that are used extensively by subyearling UWR Chinook salmon (Johnson et al. 2018, PNNL and NMFS 2018, 2020). Although yearling Chinook salmon migrants are less likely to enter and rear in these areas, the large amounts of prey (particularly chironomid insects) exported from restored wetlands to the mainstem are actively consumed by both yearling and subyearling smolts. The resulting growth likely contributes to survival at ocean entry (PNNL and NMFS 2020). The resulting growth of these fish likely contributes to survival at ocean entry (PNNL and NMFS 2020).

As discussed in Section 2.13.2.3 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, the levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, and they are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.13.2.7 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect natural populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Salmon and steelhead smolt hatchery releases throughout the Columbia River basin have likely reduced the productivity of natural populations via density-dependence, predation, and increased competition for limited resources (LCREP 2011, NMFS 2017i). NMFS directs Federal funding to many of the hatchery programs in the lower Columbia River through the Mitchell Act. NMFS completed a biological opinion on its funding of the Mitchell Act program in 2017 (NMFS 2017i). As a result of this consultation, several reform measures are being implemented that will reduce the effects of hatchery supplementation on natural-origin populations. These measures include changing broodstock management to better align hatchery broodstocks with the diversity of natural-origin population, and reducing the genetic and ecological risk by modifying the number of hatchery fish produced and released.

NMFS (2019f) recently completed consultation on the effects of the Corps' hatchery programs for spring Chinook salmon, summer steelhead, and rainbow trout in the upper Willamette River basin. We described ongoing concerns about the management of these hatchery broodstocks to minimize genetic drift and domestication given the low numbers of natural-origin salmon available for incorporation in the recent past. The Corps proposed to incorporate natural fish into the hatchery broodstocks under specific circumstances so the proportionate natural influence would increase in the near term. In determining that the proposed action avoided jeopardizing the survival and recovery of the listed species, NMFS stated that allowing some impact on the natural populations through broodstock collection will provide genetic benefits to the population while minimizing demographic risks to the extent possible, aiding in the species' recovery, particularly because these programs are being used for reintroduction above the Federal dams. This change in hatchery practices will allow natural selection to dominate in an integrated population of hatchery and natural salmon on the spawning grounds.

2.13.2.8 Recent Ocean and Lower River Harvest

Ocean fishery harvest of UWR spring Chinook salmon is typically in the range of 9 to 15 percent, under current agreements in the Pacific Salmon Treaty. The anticipated harvest rate for UWR spring Chinook salmon in the proposed mainstem Columbia River fisheries in 2018 to 2027 ranges from 5 to 11 percent and will not exceed an overall combined harvest rate of 15 percent from all freshwater fisheries combined. The 2018 Agreement proposes to continue adhering to these harvest limits for UWR Chinook salmon (NMFS 2018a). Harvest rates in freshwater fisheries have averaged 9.5 percent since 2008 (TAC 2017, NMFS 2018a) while in-ocean fisheries have averaged 9.5 percent since 2009 (PSC CTC 2017).

2.13.2.9 Predation

2.13.2.9.1 Avian Predation

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including UWR Chinook salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island, where marine forage fish were available to diversify the tern diet. Roby et al. (2017) estimated that terns on East Sand Island consumed an average of 5.1 million smolts per year, a 59 percent reduction compared to when the colony was on Rice Island.

Evans and Payton (2020) estimated predation rates by East Sand Island Caspian terns for UWR Chinook salmon using a model that adjusts for tag deposition rates as described above for Interior Columbia ESUs/DPSs. Average annual predation rates were 1.4 percent during the pre-management and 1.7 percent during the management period (Evans and Payton 2020) (Appendix B). The difference was not statistically credible. Another 1,000 terns tried to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers in 2018 and 2019 (Harper and Collis 2018, USACE 2019), further increasing effects on UWR Chinook salmon compared to the pre-management period.

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. The average annual predation rate by this colony on UWR Chinook salmon in 2003 to 2014 was 1.8 percent. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[422] where smolts are likely to constitute a larger proportion of the cormorant's diet. The annual average predation rates on UWR Chinook salmon reported by Evans and Payton (2020) for the East Sand island cormorant colony were statistically similar during the first post-management period (2015 to 2017; 1.4 percent). Insufficient numbers of PIT tags from UWR Chinook salmon were collected at this colony during the second management period to derive an average annual predation estimate.

<u>Compensatory Mortality and Avian Predation Management</u>

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on UWR Chinook salmon after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts overestimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling

[422] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead; and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two modeling frameworks used different but related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., had no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns (an additive effect). But the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, will also be important.[423]

With respect to management of terns in the estuary, Caspian terns nesting on East Sand Island were eating an annual average of 1.4 percent of juvenile UWR Chinook salmon outmigrants before management actions reduced the size of that colony, and 1.7 percent per year thereafter, which is not a statistically credible difference (Evans and Payton 2020). Therefore, there is no evidence that this management measure contributed to increased adult returns for UWR Chinook salmon, regardless of the likelihood of compensatory effects. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates from 1.8 percent to 1.4 percent, which is also not a statistically credible difference. In addition, smolt predation rates by cormorants are likely to have increased because thousands of birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[424]

2.13.2.9.2 Fish Predation

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat

[423] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

[424] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). On average, 43 adult Chinook salmon, plus 18 jacks, and 104 juveniles were killed and/or handled each year in the Sport Reward Fishery during 2014 to 2018. The fishery is conducted over a much larger area than that occupied by UWR Chinook salmon, but some of these fish could be UWR Chinook salmon.

Juvenile salmonids are also consumed by nonnative fishes, including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these fish in the lower Columbia River may incrementally improve juvenile Chinook salmon survival.

The removal of the larger, piscivorous individuals from northern pikeminnow populations may result in a sustained survival improvement for migrating juvenile Chinook salmon, but only if it is not offset by a compensatory response from remaining northern pikeminnow or other piscivorous fishes (walleye, smallmouth bass, etc.). Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Williams et al. (2017) also documented increased numbers of smallmouth bass in parts of the lower Columbia River. In 2019, Winther et al. (2019) reported smallmouth bass as having the greatest overall predatory impact of all piscivorous species monitored by the NPMP. These increases could be a compensatory response to the NPMP removal efforts or could be due to factors such as alterations in other parts of the food web or environmental conditions like warmer temperatures which affect this species' consumption rates.

Despite these trends in recent years, evidence of a compensatory response to pikeminnow removal remains unclear. However, NPMP fishery evaluation demonstrates that the Sport Reward Fishery and the Dam Angling Program are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018). Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the Chinook salmon that are "saved" from predation by pikeminnows survive to ocean entry or to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity for UWR Chinook salmon. As such, it likely continues to benefit the ESU.

2.13.2.9.3 Pinniped Predation

California sea lions and Steller sea lions aggregate each spring in the Columbia River and below Willamette Falls on the lower Willamette River, where they feed on adult Chinook salmon. Thirty-nine identifiable California sea lions and four branded Steller sea lions were documented at Willamette Falls in 2019 (ODFW 2019a). A total of 478 marked spring Chinook salmon representing 4 percent of potential escapement above falls were consumed in 2019 (ODFW 2019b). While California sea lion observations have increased in the last decade in the Columbia River Basin, recent declines in pup production and survival suggest the population may have reached carrying capacity and stopped growing (Carretta et al. 2013).

NMFS' NWFSC began studying the losses of adult spring- and summer-run Chinook salmon to sea lions between the mouth of the Columbia River and Bonneville Dam in 2010. Average natural mortality for adult spring Chinook through this reach ranged from 20 to 44 percent, generally increasing through 2015 (Rub et al. 2019). Up to 50 percent of the mortality of adult spring- and summer-run Chinook salmon destined for tributaries above Bonneville Dam occurred within the 10-mile reach just below the dam, so mortality for UWR Chinook would likely be much lower than those reported in Rub et al. (2019).

Adult UWR Chinook salmon are also vulnerable to predation throughout the lower Willamette River. This vulnerability is primarily for spring-run populations that migrate during May and June, when pinniped abundance is highest (Rub et al. 2019). Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Willamette Falls Dam and Astoria, from hazing to removal. In December 2018, ODFW was granted authorization to begin removing California sea lions preying on threatened salmon and steelhead below Willamette Falls. In 2019, the State of Oregon euthanized 33 individually identifiable predatory California sea lions that were having a significant negative impact on ESA-listed salmonids at Willamette Falls (ODFW 2019a). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between RM 112 and McNary

Dam (RM 292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

2.13.2.10 Research, Monitoring, and Evaluation Activities

The primary effects of past and present CRS-related RME programs on UWR Chinook salmon are those associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates, and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr

2019). It is likely that some of these were UWR Chinook salmon. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the NPMP in its entirety is likely to benefit the UWR Chinook salmon ESU by reducing predation throughout the Columbia River migration corridor.

For all other CRS-related RME programs, we estimated the number of UWR Chinook salmon that have been handled (or have died) each year during the implementation of RME as the average annual take reported for 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- No UWR Chinook salmon were handled during activities associated with the Smolt Monitoring Program and the CSS.
- Average annual estimates for UWR Chinook salmon handling and mortality for all other RME programs were as follows:
    - 35 hatchery and 12 natural-origin adults were handled.
    - One hatchery and one natural-origin adult died.
    - 23 hatchery and 353 natural-origin juveniles were handled.
    - No hatchery or natural-origin juveniles died.

The combined take (i.e., handling, injury, and incidental mortality) of UWR Chinook salmon associated with these elements of the RME program has, on average, affected less than 1 percent (0.08 percent) of the natural-origin adult run (recent, 5-year average) and 0.03 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities, and therefore negatively affects UWR Chinook salmon.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the ESU level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.13.2.11 Critical Habitat

The condition of UWR Chinook salmon critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized here in Table 2.13-2. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for UWR Chinook salmon production have been weakened. Conditions in the portion of the lower Columbia River rearing habitat and migration corridor designated as critical habitat (i.e., the mainstem of the Columbia River below the confluence of the Willamette River) were substantially affected by the development and operations of upstream storage reservoirs and the principal effect on the migration corridor PBF is altered mainstem flows. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for UWR Chinook salmon have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.13-2. Physical and biological features (PBFs) of designated critical habitat for UWR Chinook salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF in the Action Area
Freshwater spawning	Substrate, adequate water quality and water quantity.	Freshwater spawning sites used by UWR Chinook are in tributaries to the Willamette River and are not within the action area for this consultation. The Willamette Project flood control/water supply/hydropower dams obstruct access to spawning habitat in the four historically most-productive tributaries to the Willamette River and reduced water quality and quantity in the remaining areas downstream. Land use practices including urban development, agriculture, timber harvest, mining and grazing, and bank hardening have obstructed access to historically productive spawning habitats and reduced water quality, water quantity, and substrate (spawning gravels) in the remaining areas.
Freshwater rearing	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and	Much of the freshwater rearing habitat used by UWR Chinook salmon is in tributaries to the Willamette River and are not within the action area for this consultation. The Willamette Project flood control/water supply/hydropower dams obstruct access to rearing

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF in the Action Area
	mobility, water quality, forage, and natural cover.	habitat in the four historically most-productive tributaries to the Willamette River and reduced water quality and quantity in the remaining areas downstream. Land use practices including urban development, agriculture, timber harvest, mining and grazing, and bank hardening have obstructed access to historically productive rearing habitats and reduced water quality, water quantity, and substrate (spawning gravels) in the remaining areas. See also "estuarine areas."
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover.	Alteration of the seasonal flow regime in the lower Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderate negative effect in lower flow years for all populations. Alteration of the seasonal mainstem temperature regime in the lower Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring, when juvenile adult spring-run Chinook salmon are migrating, and warmer temperatures in the late summer and fall, compared to historical conditions (hydrosystem development and operations).[1] Reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (hydrosystem development) may have reduced "natural cover" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining) affects all populations.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, juvenile and adult forage.	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects), have reduced access to floodplain habitat for rearing and prey production and the quantity and quality of estuarine rearing areas. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling Chinook salmon by more than 2.5 percent. Another 2,500 acres of

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF in the Action Area
		currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the Caspian Tern and Double-crested Cormorant management plans for the colonies on East Sand Island does not appear to have reduced predation rates on juveniles from this ESU. Predation rates for birds foraging from the Astoria-Megler Bridge are likely to be even higher than for cormorants foraging from East Sand Island. Observations of increased pinniped predation and risk for spring migrating adult Chinook salmon in the lower Willamette and Columbia Rivers.
Nearshore marine areas[2]	Free of obstruction and excessive predation with water quality, quantity, and forage.	Concerns about increased pinniped predation and adequate forage. Reduced quality of nearshore marine areas.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as June or July.

[2] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.13.2.12 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of UWR Chinook salmon, including recent biological opinions issued for UWR Chinook salmon and key emergent or ongoing habitat concerns (NMFS 2016e). From January 2015 through May 22, 2020, we completed 482 formal consultations that addressed effects to UWR Chinook salmon.[425] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects

[425] PCTS data query, July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). UWR Chinook salmon are exposed to the effects of this 2008 action when they are migrating through the lower Columbia River downstream from Portland. Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat, improve riparian condition outside of the action area, and increase channel complexity and instream flows throughout the Columbia River Basin. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration; some of these projects are likely to benefit UWR Chinook salmon. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some of these projects, especially projects in the estuary, are likely to provide beneficial effects for UWR Chinook salmon. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., reduced obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.13.2.13 Summary

Altogether, the stressors described above for each life stage of UWR Chinook salmon are expected to continue. The status of the species is continuing to decline, even with major management reforms. Although structural improvements for adult salmon collection and transport have been implemented at Minto, Foster, Cougar, and Fall Creek Dams, juvenile downstream passage through the reservoirs and dams remains the primary limiting factor for these populations. For UWR Chinook salmon residing below these dams, pre-spawning mortality rates are high and habitat quantity and quality issues persist. Low numbers of natural-origin salmon coupled with high numbers of hatchery-origin salmon result in a high proportion of hatchery-origin fish on the spawning grounds. The small net improvement in floodplain connectivity achieved through the CRS estuary habitat program and efforts to improve hatchery practices and lower harvest rates are positive signs, but these stressors continue to negatively impact survival. Other stressors like past land development, habitat degradation, and predation, in combination with the potential effects of climate change (NMFS 2016e), will also continue to negatively affect UWR Chinook salmon (NMFS 2016e).

Likewise, the environmental baseline does not fully support the conservation value of designated critical habitat for UWR Chinook salmon, as described above. The PBFs essential for the conservation of this species include freshwater rearing areas, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (i.e., at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in the last two decades to improve the functioning of some of the PBFs of critical habitat. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. For subyearling smolts, restoration projects in the estuary are improving the functioning of areas used for growth and development. However, the factors described above continue to have negative effects on these PBFs.

2.13.3 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.13.3.1 Effects to Species

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams in an attempt to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns.[426] Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG gas cap spill

[426] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

for a minimum of 16 hours per day, and may operate under "performance standard spill" for up to 8 hours per day. John Day Dam will spill up to120 percent TDG gas cap spill for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill. Bonneville Dam will spill up to 125 percent TDG (with a 150 kcfs spill constraint) and 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in these periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under the higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.13-3.

Table 2.13-3. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.13-4. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.13-4. Proposed summer spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[2]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March; decreased flows from May through August, and little change in flows in April and September) described in the environmental baseline will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.

- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse operations are intended to benefit resident species. The change in Libby operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce winter spill events (and associated elevated TDG levels), which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries when TDG is excessive. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.13-3).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

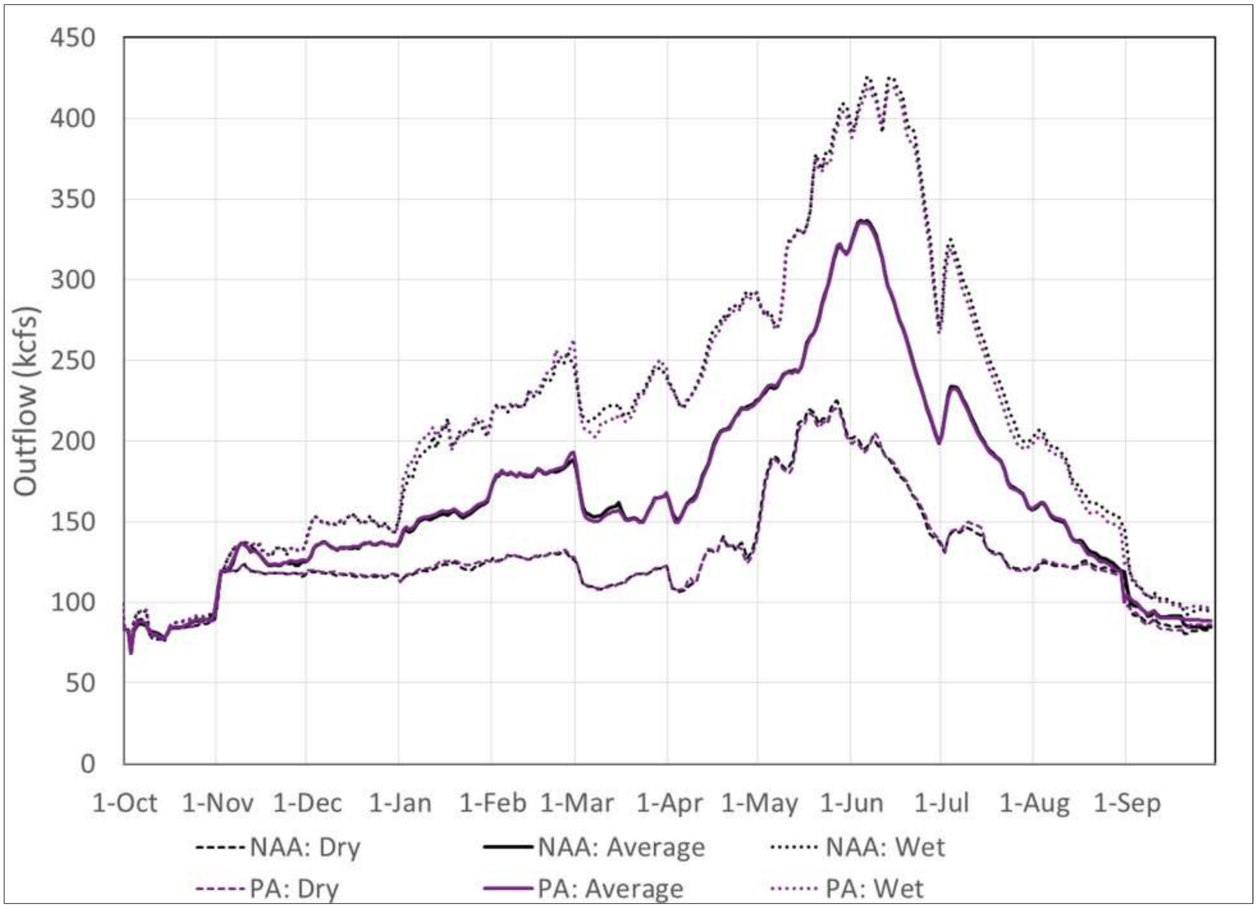

Figure 2.13-3. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

These proposed changes in reservoir operations are not likely to meaningfully affect the probability of meeting spring or summer flow objectives, and associated effects on UWR Chinook smolts or adults by a meaningful amount.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[427] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges

[427] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Given the EPA's analysis supporting discharge limits for oil and grease at the lower Snake and Columbia River projects, the large flow volume of the lower Columbia River, the distances between the CRS projects and the Willamette River confluence, and the fact that few UWR steelhead adults have been observed moving upstream of Bonneville, any impacts of oil and grease on UWR Chinook salmon are likely to be negligible.

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency hypothetically increases the exposure of UWR Chinook salmon juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile UWR Chinook salmon spend days to months in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

The effects of the proposed hydrosystem operations and the non-operational measures on UWR Chinook salmon and its habitat are described below.

2.13.3.1.1 Hydrosystem Operation

For UWR Chinook salmon, the effects of the proposed hydrosystem operations will generally be consistent with recent operations and mitigation measures, with the addition of the proposed flexible spill operation. We assume that very small numbers of adults will pass over Bonneville Dam during implementation of the proposed action, comparable to the numbers reported for the last 10-year period (less than one fish per year). These will be lost from their respective spawning populations, but this is unlikely to affect the abundance or productivity of those populations.

During periods of increased spill each spring, levels of TDG up to 125 percent will extend for at least 35 miles downstream of Bonneville Dam (Camas-Washougal gauge). A small number of adult UWR Chinook salmon are likely to stray past the Willamette confluence and be exposed to these conditions. To the extent that adult individuals stray and move further upstream in the Columbia River, exposure will be increased. There will be no exposure to elevated TDG levels associated with periods of increased spring spill levels for juveniles migrating and rearing in the Columbia River downstream of the Willamette River confluence because TDG effects will dissipate by the time the flows reach the Willamette confluence.

The effects of continuing the CRS operations will include greater than natural flows in the action area during the months of October through March, when some juvenile UWR Chinook salmon migrants are present in the estuary (Schroeder et al. 2015). The continued changes in flow may alter the fitness of some individual fish (faster migration to the ocean), but we do not expect increased mortality from these changes. Similarly, juveniles will not be exposed to the proposed changes in the hydrosystem operations (increased spring spill, increased John Day Pool, transportation, reduced summer spill) or continued maintenance and operation of the fish passage facilities.

The proposed operations at Libby and Hungry Horse Dams should not have any substantial effect on summer flow. The proposed operation at Grand Coulee Dam should not affect juvenile migration or survival because the operations would only have a minimal effect on summer flow, primarily in August, which is not when these fish migrate. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would be small and would occur in high flow years and thus not add risk to these juvenile migrants.

The proposed operations at Libby and Hungry Horse Dams should not have any substantial effect on summer flow. The proposed operation at Grand Coulee Dam will have a very slight effect on summer flow, primarily in August, which is not when these fish migrate. The proposed operation at Dworshak Dam should not affect adults because any potential flow reduction would occur in high flow years during the spring and would not affect the migration or survival of these adults.

2.13.3.1.2 Predation Management and Monitoring Actions

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions will continue current levels of predation at this colony, but as discussed in the Environmental Baseline section, implementation does not appear to have reduced predation rates on this ESU. We expect that cormorant predation in the estuary may be an increasingly important source of mortality for UWR Chinook salmon, because large numbers of these birds are now foraging from the Astoria-Megler Bridge, where predation rates are likely to be higher.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none have been proposed at this time.

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. This fishery removes approximately 10 to 20 percent of predator-sized pikeminnow per year and is open from May through September. We estimate that no more than 100 adult (including jacks) and 200 juvenile Chinook salmon, including some UWR Chinook salmon, will be caught incidentally by the Sport Reward Fishery (or an alternative pikeminnow removal strategy) per year. A portion of these fish may include UWR Chinook salmon. These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including UWR Chinook salmon. Only a very few individual adult UWR Chinook salmon that stray past the Willamette River confluence will be exposed to the proposed pinniped management activities near Bonneville Dam.

2.13.3.1.3 Habitat Actions

The tributary habitat improvements will not target any tributaries that provide habitat for UWR Chinook salmon and, thus, will not affect this ESU.

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and improve access to these resources for juvenile salmonids. Estuary habitat conditions are especially important for subyearling UWR Chinook salmon and ODFW and NMFS (2011) considered altered hydrology and flow timing in the estuary, as well as loss of side channel and wetland habitat, a primary limiting factor for this life-history component of the ESU.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty in predicting the timing and accomplishment of habitat restoration actions and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site-specific conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway. Continued implementation of this monitoring program will either confirm that these floodplain reconnections are enhancing conditions for salmonids such as UWR Chinook salmon as they rear and migrate through the mainstem or provide sufficient information to the Action Agencies that site selection or project design can improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during the period covered by this consultation and beyond.

With these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during the period of the proposed action, increasing the availability of rearing habitat and the flux of insect and amphipod prey to the mainstem migration corridor to juvenile UWR Chinook salmon. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[428] of all UWR Chinook salmon populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and any resulting trends.

[428] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile Chinook salmon opportunities to move into wetland habitats for food and refuge from predators. Moreover, the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the UWR Chinook salmon ESU.

2.13.3.1.4 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for the impacts of the construction of the CRS have completed section 7 consultations (e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action (BPA et al. 2020, USACE 2020) will have the same effects as those described generally in the Environmental Baseline section and in detail within the site-specific biological opinions referenced therein (see Section 2.13.2.7). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here. Hatchery production funded by the Corps in the Upper Willamette River basin is associated with the Willamette Project dams and is not an effect of this proposed action. The Corps' Upper Willamette hatchery programs have undergone Section 7 consultation (NMFS 2019f).

2.13.3.1.5 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult UWR Chinook are likely to be present in shallow shoreline areas, an unknown portion of the ESU will continue to be stunned, harmed or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this ESU that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[429]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level.

[429] Ongoing and future discussions are expected to lead to substantial reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of UWR Chinook salmon will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS:
  - Zero hatchery and natural-origin adults and juvenile will be handled and/or will die.
- Activities associated with all other RME programs include:
  - 200 hatchery and 200 natural-origin adults will be handled.
  - 10 hatchery and 10 natural-origin adults will die.
  - 5,000 hatchery and 1,000 natural-origin juveniles will be handled.
  - 50 hatchery and 50 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program will, on average, affect 1.2 percent of the natural-origin adult (recent, 5-year average) run and 0.08 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to much less than 1 percent of estimated ESU abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the small effects of the RME programs on abundance are acceptable and warranted.

2.13.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation will not affect the functioning of the juvenile or adult migration corridors for UWR Chinook salmon. Implementation will affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River estuary for all populations. Effects of the proposed action on the PBFs are described in Table 2.13-5.

Table 2.13-5. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the UWR Chinook salmon ESU.

PBF	Effect of the Proposed Action
Freshwater spawning sites	Freshwater spawning sites used by UWR Chinook salmon are in tributaries to the Willamette River and will not be affected by the proposed action.
Freshwater rearing sites	Much of the freshwater rearing habitat used by UWR Chinook salmon is in tributaries to the Willamette River and will not be affected by the proposed action. See also "estuarine areas."
Freshwater migration corridors	Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies' ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. Continued alteration of the seasonal mainstem temperature regime in the Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and early summer, when juveniles and adult UWR Chinook salmon are migrating. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of proposed operations. In general, cooler spring temperatures will not adversely affect the functioning of the mainstem as a migration corridor for juveniles or adults. Proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but will not change the functioning of water quantity in the juvenile and adult migration corridors. Continued reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (ongoing reduction in "natural cover"). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued implementation of the Action Agencies' bird, fish, and pinniped predator management programs will continue recent levels of predation in the juvenile and adult migration corridors.
Estuarine areas	Continued improvement in access to floodplain habitat for rearing and prey production with implementation of the estuary habitat program will further improve access to natural cover, aquatic vegetation, and side channels and juvenile and adult forage). This will increase opportunities for subyearling Chinook salmon to access sites used for growth and for the transition to life in the ocean and will increase access to prey for yearling Chinook that remain in the mainstem. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation

PBF	Effect of the Proposed Action
	in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.13.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.13.1), Environmental Baseline (Section 2.13.2), and Effects of the Action (Section 2.13.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation), various stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including UWR Chinook salmon.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of the activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.13.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.13.5.1 Species

The UWR Chinook salmon ESU comprises seven populations in a single MPG. All populations are at very low abundance, with the exception of the Clackamas and McKenzie populations. Tributary dams have blocked access to important spawning and rearing habitat and affected flow and temperature regimes downstream of the projects. The other primary factors for decline (e.g., water quality and other aspects of habitat quality) occur also in the tributaries, upstream of the effects of the proposed action. In the past 5 years for which data is available (2014-2018), the Clackamas population has remained relatively abundant and stable, and the natural-origin components of the McKenzie, North Santiam, South Santiam, and Middle Fork Willamette populations have remained at similar or lower levels, compared to earlier abundance estimates. Recent poor ocean conditions associated with a marine heatwave and its lingering effects have likely contributed to lower than average ocean survival rates in recent years. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants.

The proposed 125 percent TDG spring spill operation should further increase spill levels at Bonneville Dam (limited to 150 kcfs), which will increase juvenile exposure to TDG for the few adult UWR Chinook salmon that occasionally pass upstream of Bonneville Dam. Other operations (e.g., Upper Columbia operations to better protect resident species, Dworshak Dam winter operations to reduce TDG in the lower Clearwater River, etc.) could, collectively, have a small, negative effect (slightly reduced flow), especially on juvenile migrants. However, these effects should not measurably alter juvenile survival rates.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing conditions. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving UWR Chinook salmon abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this ESU. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies' proposal to continue implementing the Caspian Tern Nesting Habitat Management Plan and the Double-crested Cormorant Management Plan is likely to continue current levels of predation by terns and cormorants. However, there is no evidence that management of the East Sand Island tern colony has reduced predation rates on UWR Chinook salmon, and cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that likely prey on juvenile UWR Chinook salmon are also present in the Lower Columbia River. The NPMP is expected to continue providing similar benefits of predator removal (northern pikeminnow), maintaining current (reduced) levels of predation and creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on UWR Chinook salmon in the lower Willamette River and Columbia River and estuary has increased substantially with recent increases in the abundance of sea lions, especially in the spring. Sea lion predation will continue to substantially and negatively affect the productivity and abundance of UWR Chinook salmon.

The management of UWR Chinook salmon hatchery programs is expected to improve compared to historical operations. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of UWR Chinook salmon.

Harvest rates on UWR Chinook salmon in both ocean and freshwater fisheries have decreased greatly compared to historical levels, but remain substantial. Both ocean harvest and freshwater harvest rates have averaged nearly 10 percent (each) since 2009 and are expected to continue at these levels.

As described in Section 2.13.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area considered for UWR Chinook salmon are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect UWR Chinook salmon in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of UWR Chinook salmon as moderate. We generally expect that abundance could somewhat decrease and extinction risk increase as a result of climate change.

Migrating adults could potentially respond temporally to changing environmental conditions by migrating earlier, but are reliant upon spring flows, and would be exposed to higher summer temperatures for longer periods of time prior to spawning. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or winter flood events). Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in streams and in the estuary. Subyearling migrants, because they typically spend little time in freshwater, would avoid exposure to higher summer temperatures, but yearling migrants would be exposed. Though the quality of information is mixed, sensitivity in the marine stage is likely high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur. NMFS’ life-cycle modeling (for SR spring/summer Chinook salmon), which considered three potential levels of changing climate severity over the next 24 years, clearly indicates that climate change effects, especially those that may manifest in the ocean, pose a substantial threat as they can have severe, negative consequences to the overall productivity (and abundance) of all SR spring/summer Chinook salmon populations (see Section 2.2.3.1.12 Life-Cycle Modeling), and likely to other “stream type” Chinook salmon populations as well. These climate change consequences are not caused by the proposed action. In simple terms, even if the adult abundance declines somewhat as a result of climate change, which will make recovery of this ESU somewhat more challenging, it will have declined no more so as a result of the proposed action.

The proposed action includes conservation measures to mitigate the potential adverse effects of the action, in many cases by addressing limiting factors for survival and recovery. These measures include estuary habitat improvement and predator management actions that should benefit VSP parameters, thus reducing the expected abundance declines caused by climate change. Collectively, the proposed action is likely to improve factors identified in the recovery plan for this ESU (e.g., degraded estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.)

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action influences freshwater survival and productivity. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., estuary habitat, predation, etc.). Evidence shows that these actions have resulted in improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. Ecosystem functions should continue to increase in estuary habitats where improvement actions occur.

Climate change is a substantial threat to UWR Chinook salmon, especially during the marine rearing phase of their life cycle. The proposed action should not exacerbate either the scope or severity of those impacts.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of UWR Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of UWR Chinook salmon.

2.13.5.2 Critical Habitat

Critical habitat for UWR Chinook salmon encompasses 11 subbasins in Oregon and Washington containing 61 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition and most of these watersheds have some, or a high, potential for improvement. Similar to the discussion above for the species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns.

The environmental baseline includes a broad range of past and present actions and activities that have affected the functioning of critical habitat for UWR Chinook salmon. These include the effects of water storage, irrigation withdrawals, and hydropower generation in the Willamette River basin and changes in tributary and mainstem habitat (both positive and negative) on freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. Land use and development activities remain a concern; these include activities that affect the quality and accessibility of habitats and habitat-forming processes, such as riparian condition and floodplain function as well as water quality. In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. Toxic contamination and urban and industrial development in the lower Willamette and Columbia Rivers are also a concern, particularly for fry migrants that spend many months rearing in these areas.

Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of Federal, state, and local agencies; tribes; and other stakeholders. A number of restoration projects have been implemented in the lower Columbia River estuary, many of these funded through the CRS program. The Action Agencies' proposed estuary habitat program will continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to juvenile Chinook salmon migrating to the ocean (improved forage in estuarine areas).

The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors below the Willamette confluence. The thermal inertia created by the CRS reservoirs will not negatively affect temperatures (water quality) in the juvenile or adult migration corridors. Thus, the proposed action is not likely to further limit water quantity in the juvenile and adult migration corridors by a meaningful amount and will not affect obstructions.

The Action Agencies will continue to implement the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the lower Columbia River, and the predation management programs for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will maintain the levels of predation in the migration corridors that were achieved in recent years, although cormorant predation rates may increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the estuary, many of these funded through the CRS program. The Action Agencies propose to continue to reconnect an average of 300 acres of the historical floodplain per year, further increasing access to rearing areas used by subyearling Chinook salmon and the availability of wetland-derived prey to yearlings (improved forage in estuarine areas) beyond the more than

6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of UWR Chinook salmon. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of UWR Chinook salmon designated critical habitat.

2.13.6 Conclusion

After reviewing and analyzing the current status of UWR Chinook salmon and its critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of UWR Chinook salmon or destroy or adversely modify its designated critical habitat.

2.14 Upper Willamette River (UWR) Steelhead

This section applies the analytical framework described in Section 2.1 to UWR steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the UWR steelhead DPS or destroy or adversely modify its critical habitat.

2.14.1 Rangewide Status of the Species and Critical Habitat

The status of the UWR steelhead DPS is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution," as described in 50 CFR 402.02. This opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.14.1.1 Status of the Species

2.14.1.1.1 Background

On March 25, 1999, NMFS listed the UWR steelhead as threatened (64 FR 14517) and reaffirmed that status on January 5, 2006 (71 FR 834). The status was upheld on April 14, 2014 (79 FR 20802). The most recent status review, in 2016, concluded that this ESU should retain its threatened status (81 FR 33468). Critical habitat for UWR steelhead was designated August 22, 2011 (76 FR 52317). The summary that follows describes the status of UWR steelhead. Additional information can be found in the recovery plan (ODFW and NMFS 2011) and the most recent status review for this species (NMFS 2016e).[430]

The UWR steelhead DPS includes all naturally spawned anadromous, winter-run *O. mykiss* originating below natural and manmade impassable barriers from the Willamette River and its tributaries upstream of Willamette Falls to, and including, the Calapooia River (Figure 2.14-1). There is only one major population group in this DPS, composed of four historical populations (Myers et al. 2006), all four populations remain extant and produce low to moderate numbers of natural-origin steelhead each year. Winter steelhead hatchery releases within the boundary of the UWR steelhead DPS ended in 1999; however, there is still a hatchery program for non-native summer steelhead.

[430] In addition, a technical memo prepared for the status review contains detailed information on the biological status of the species (NWFSC 2015).

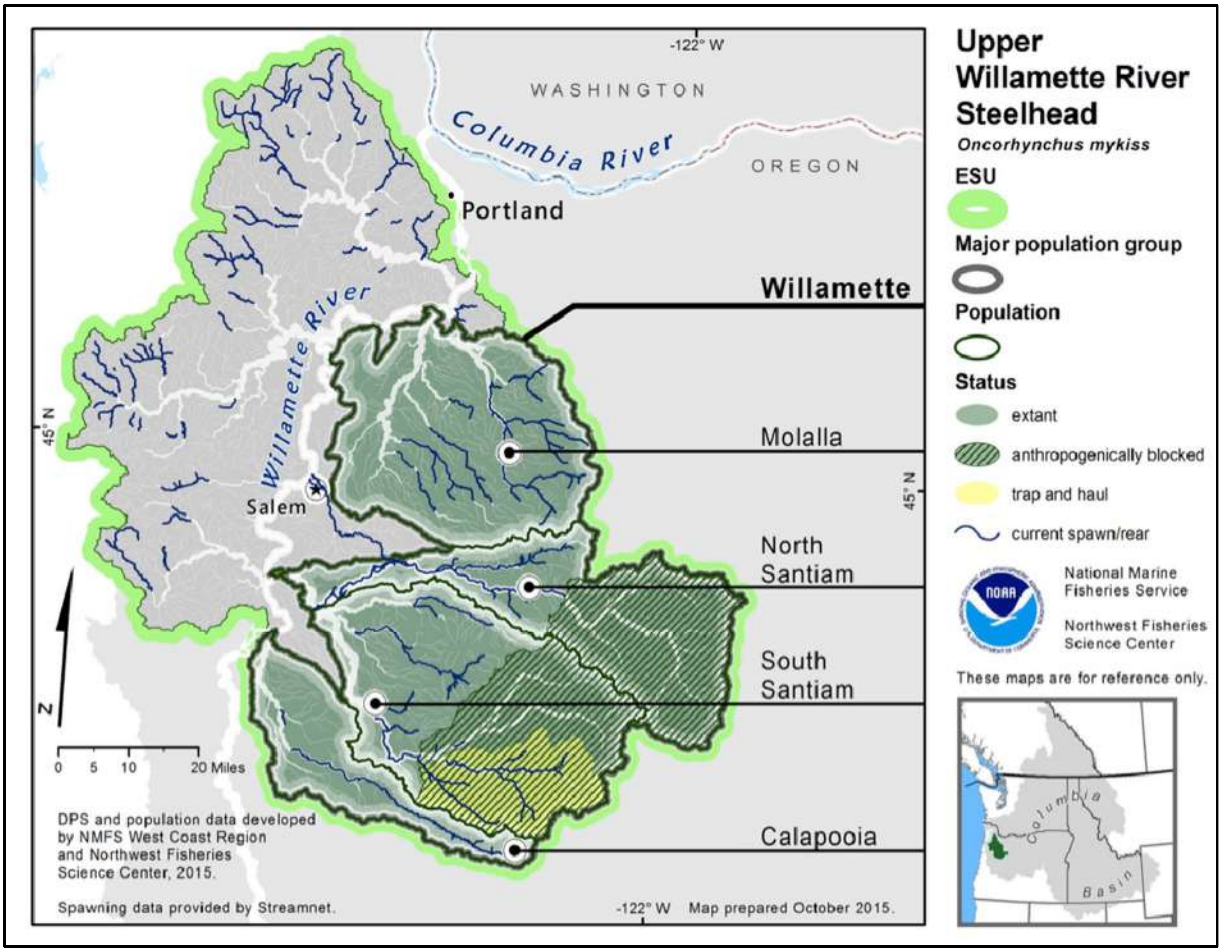

Figure 2.14-1. Map of the UWR winter steelhead DPS's spawning and rearing areas, illustrating the four populations within the one major population group. The westside tributaries of the DPS were not defined as a primary population area needed to meet recovery goals for the DPS (ODFW and NMFS 2011).

2.14.1.1.2 Life-History and Factors for Decline

Before construction of a fish ladder at Willamette Falls in the early 1900s, flow conditions allowed steelhead to ascend Willamette Falls only during the late winter and spring. As a result, UWR steelhead evolved as winter-run fish, returning to freshwater in January through April, passing Willamette Falls from mid-February to mid-May, and spawning in March through June, with peak spawning in late April and early May. They typically migrate farther upstream than Chinook salmon and can spawn in smaller, higher gradient streams and side channels. UWR steelhead may spawn more than once, although the frequency of repeat spawning is relatively low. Juvenile steelhead rear in headwater tributaries and upper portions of the subbasins for 1 to 4 years (most often 2 years), then migrate quickly downstream in April through May, through the mainstem Willamette River and Columbia River estuary and into the ocean. UWR steelhead typically forage in the ocean for 1 to 4 years (most often 2 years) and during this time are thought to migrate north to Canada and Alaska and into the North Pacific including the Alaska Gyre (ODFW and NMFS 2011).

At the time of listing of this DPS, NMFS noted concerns with genetic integrity of the DPS due to the construction of fish ladders at Willamette Falls as early as 1885, which facilitated the successful introduction of out-of-basin steelhead into the upper Willamette river basin. Also noted were blockage of historical spawning habitat by the Willamette Project dams and other smaller dams or impassable culverts throughout the region, and habitat degradation related to forestry, agriculture, and urbanization in the Willamette Valley. After fluctuating for several decades, abundance of natural-origin winter steelhead ascending the Willamette Falls fish ladder had been declining steeply since 1988, and the run in 1995 was the lowest in 30 years (Busby et al. 1996, 63 FR 11798).

2.14.1.1.3 Recovery Plan

The ESA recovery plan for UWR steelhead (ODFW and NMFS 2011) includes delisting criteria for the DPS, along with identification of factors currently limiting its recovery, and management actions necessary for recovery. The biological delisting criteria are based on recommendations by the W/LC TRT. They are hierarchical in nature, with DPS-level criteria based on the status of natural-origin UWR steelhead assessed at the population level. Population-level assessments are based on evaluation of population abundance, productivity, spatial structure, and diversity (McElhany et al. 2000) and an overall extinction risk characterization. Achieving recovery (i.e., delisting) of the DPS will require sufficient improvement in its abundance, productivity, spatial structure, and diversity.

2.14.1.1.4 Abundance, Productivity, Spatial Structure, and Diversity

In its most recent status review for UWR steelhead (NMFS 2016e), NMFS noted that overall, the declines in abundance noted during the previous review (Ford et al. 2011) had continued through the period 2010 to 2015, and that populations in this DPS had experienced long-term declines in spawner abundance. Although the declines noted were relatively moderate, the most recent review noted that continued declines would be a cause for concern (NWFSC 2015). The most recent review noted considerable uncertainty in many of the abundance estimates for this DPS (with the possible exception of tributary dam counts). Radio-tagging studies suggested that a considerable proportion of winter-run steelhead ascending Willamette Falls do not enter the spawning areas that constitute this DPS; the review noted that these fish might be non-native, early winter-run steelhead that have colonized the western tributaries, misidentified summer-run steelhead, or late winter-run steelhead that have colonized tributaries not historically part of the DPS (NWFSC 2015).

In terms of spatial structure, access to historical spawning and rearing areas remained restricted by large dams in the North and South Santiam subbasins. The most recent status review noted that improvements to fish passage at Bennett Dam and operational temperature control at Detroit Dam might be providing some stability in abundance for the North Santiam River population, but that it was unclear if sufficient high quality habitat was available below Detroit Dam to support the population reaching its recovery goal. Similarly, the most recent status review noted that the South Santiam River population might not be able to achieve its recovery goal without access to historical spawning and rearing habitat above Green Peter Dam and/or improved juvenile downstream passage at Foster Dam (NWFSC 2015).

The most recent status review noted that winter steelhead hatchery programs in the Upper Willamette River basin had been terminated in the late 1990s, an action that would help to alleviate diversity concerns related to hatchery fish. At the time of the most recent status review, the only steelhead programs in the upper Willamette River were releasing non-native summer steelhead. Annual total releases had been relatively stable at around 600,000 fish since 2009, although the distribution had changed, with fewer fish being released in the North and South Santiam Rivers and corresponding increases in the McKenzie and Middle Fork Willamette Rivers. There was some concern regarding the effect of introduced summer steelhead on native late-winter steelhead (NWFSC 2015).

Overall, NMFS concluded in the most recent status review that none of the populations in the DPS were meeting their recovery goals and that all were most likely in the moderate risk category (NWFSC 2015, NMFS 2016e).

2.14.1.1.5 Limiting Factors

Understanding the limiting factors and threats that affect the UWR steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. The recovery plan for UWR steelhead (ODFW and NMFS 2011) identifies key and secondary limiting factors and threats for each population by area and life stage. These include:

- Restricted access to historical spawning and rearing habitat in the North and South Santiam subbasins by the Willamette Project flood control/hydropower dams operated by the Corps. Willamette Project dams block or delay adult fish passage to major portions of the historical holding and spawning habitat for UWR steelhead in the North Santiam and South Santiam subbasins. In addition most Willamette Project dams have limited facilities or operational provisions for safely passing juvenile steelhead downstream of the facilities. In the absence of effective passage programs, UWR steelhead will continue to be confined to lowland reaches, where land development, water temperatures, and water quality are limiting, and where pre-spawning mortality levels are generally high (NMFS 2016e).
- Hydropower-related limiting factors extend to the Columbia River estuary, where adverse effects on estuarine habitat quality and quantity are related to the cumulative effects of Columbia River basin dams. Effects include an altered seasonal flow regime and Columbia River plume due to flow management (ODFW and NMFS 2011).
- Land use practices including agriculture, timber harvest, mining and grazing activities, diking, damming, development of transportation, and urbanization, which have reduced

access to historically productive habitats and reduced the quality of remaining habitat by weakening important watershed processes and functions (ODFW and NMFS 2011).

- Predation by birds, native and non-native fish, and marine mammals, including increasing marine mammal predation at Willamette Falls (NMFS 2016e, Brown et al. 2017). Piscivorous birds, including Caspian terns and cormorants, and fishes, including northern pikeminnow, take significant numbers of juvenile steelhead. Steelhead smolts are especially vulnerable to Caspian tern predation in the Columbia River (Evans et al. 2018). Pikeminnow are significant predators of yearling juvenile migrants in the Willamette and Columbia Rivers (Friesen and Ward 1999). The magnitude of pinniped predation for UWR steelhead in the estuary is not known, though the presence of California sea lions and Steller sea lions at the Astoria Mooring Basin has been increasing over the past few years. Similarly, the number of sea lions observed at Willamette Falls has also been increasing.
- The presence of hatchery-reared and feral hatchery-origin fish that may affect the growth and survival of juvenile late-winter steelhead. In the North and South Santiam Rivers, juveniles are largely confined by dams to below much of their historical spawning and rearing habitat. Releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter juvenile steelhead.
- Historical harvest, although significant reforms were implemented in the early 1990s, and whereas harvest may have been a listing factor for winter steelhead, the reforms that have been implemented have reduced fishery harvest impacts such that it is no longer identified as a limiting factor. The current exploitation rates on natural-origin steelhead from sport fisheries are in the range of 0 to 3 percent, and steelhead are not intercepted in ocean fisheries to a measurable degree. There is some additional incidental mortality in the commercial net fisheries for hatchery Chinook salmon and steelhead in the lower Columbia River (ODFW and NMFS 2011).
- Climate change effects, including increased stream temperatures, changes in precipitation/streamflow, and years of low ocean productivity (NMFS 2016e).

2.14.1.1.6 Information on Status of the Species since the 2016 Status Review

Abundance data for UWR steelhead are available from counts at the Willamette Falls fishway. UWR steelhead as counted at Willamette Falls were at a relatively steady but low abundance at the time of the most recent status review (NMFS 2016e). Since then, counts of adult UWR steelhead at Willamette Falls have declined dramatically, with 2017 and 2018 counts reaching only 15 to 30 percent of the 5-year geometric mean for the years 2010 through 2014 (Table 2.14-1).

Table 2.14-1. UWR Steelhead adult abundance at Willamette Falls. The 5-year geometric mean of Willamette Falls counts from 2010 through 2014 was calculated at the time of the last status review (NWFSC 2015). Counts for later years were obtained from the Willamette Falls annual fish counts (NMFS 2019g, ODFW 2020).

5-Year Geometric Mean	Total Natural-Origin Adults
2010-2014	6,164
2015-2019	2,628

It is likely that any recent downturn is linked to poor ocean conditions, as described above for other steelhead species. These conditions (e.g., temperature and salinity, coastal food webs) appeared to be more favorable to steelhead survival and adult returns in 2018, but were still impacted by recent warming trends.

NMFS will evaluate the implications for extinction risk of these more recent returns, and additional data at the population level, in the upcoming 5-year status review, expected in 2021. The status review will consider new information on population abundance productivity, diversity, and spatial structure.

2.14.1.2 Status of Critical Habitat

NMFS (2005b) designated critical habitat for UWR steelhead to include all estuarine areas and river reaches from the mouth of the Columbia River upstream to the confluence of the Willamette River (50 CFR 226.212(r)). Critical habitat for UWR steelhead encompasses seven subbasins in Oregon as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2016e) and have some, or high, potential for improvement. Similar to the discussion above regarding effects on the species, the status of critical habitat is likely to be affected by climate change, with predicted rising temperatures and alterations in stream flow patterns. Improved access to spawning and rearing habitat, and habitat restoration efforts, will help reduce those effects on critical habitat.

Of 28 designated HUC5[431]watersheds, NMFS (2005b) gave 15 a high rating, six a medium rating, and seven a low rating for their value to the conservation (i.e., recovery) of the species. The rating process considered the quantity and quality of habitat features, the relationship of the area to others within the species' range, and the significance of the population occupying that area as a factor in its recovery. Thus, even a location with poor quality habitat could have a high conservation value if it is essential due to factors such as limited availability (e.g., one of few remaining spawning areas), a unique contribution of the population it serves (e.g., a population at

[431] A HUC is a Hydrologic Unit Code, developed by the U.S. Geological Survey as a standardized way of identifying drainage basins, subbasins, and watersheds throughout the country. A HUC5 is a five-unit (5 two-digit numbers) code. Examples are "Salmon River-Redfish Lake Creek" (1706020102) in the upper Salmon River basin, Idaho; "Wenatchee River—Icicle Creek" (1709000501) in the Wenatchee Basin, Washington.

the extreme end of the species' geographic distribution), or if it plays another important role (e.g., obligate for migration between the ocean and upstream spawning and rearing areas).

In evaluating the quantity and quality of habitat features NMFS (2005b) examined the condition of the PBFs. The PBFs are essential to conservation because they support one or more of the species' life stages (NMFS 2005b), described below:

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.
- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.
- Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.
- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.

- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels. As in the case of freshwater migration corridors and estuarine areas, nearshore marine features are essential to conservation because without them juveniles cannot successfully transition from natal streams to offshore marine areas. For this species, the designated nearshore marine area extends from the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

Critical habitat also has been designated for UWR steelhead in the lower Columbia River estuary. For the purposes of this analysis, we broadly define the estuary to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. NMFS considers the estuary to have a high conservation value because it connects every population with the ocean and is used by rearing and migrating juveniles and by migrating adults

Human activities since the late 1800s have altered its form and function, reducing the quantity and quality of its PBFs. Historically, the downstream half of the estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained this environment. Today, navigation channels have been dredged, deepened, and maintained; jetties and pile-dike fields have been constructed to stabilize and concentrate flow in the mainstem navigation channel; and causeways have been constructed that restrict the position of tributary confluences.

In addition, more than 70 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban use. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from upstream reservoirs have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased; these changes may have had important impacts on salmon diversity and productivity by changing the types of habitat available. Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington).

Dampening of established flow variations in the Columbia River estuary through flow regulation may have reduced the diversity of salmon migration patterns, with potential effects on arrival times and sizes of fish entering the estuary and ocean. Reduced floodplain inundation has eliminated shallow-water habitats, which were seasonally important rearing areas and refugia for juvenile salmonids. Disconnecting the tidal river from its floodplain also prevented delivery of woody debris, organic matter, and prey resources to the estuary, with potential consequences for estuarine food chains.

The rest of the designated areas are within the Willamette River basin, where land management activities have severely degraded stream habitat conditions in the mainstem and associated subbasins above Willamette Falls. In these areas, high density urban development and widespread agriculture have altered watershed processes, reducing aquatic and riparian habitat quality and complexity. The Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging, and other activities that have reduced rearing habitat by as much as 75 percent. In addition, the construction of 37 dams in the basin has blocked access to more than 435 miles of historical stream and river spawning habitat. Storage operations at high-head dams alter the temperature regime of the Willamette River and its tributaries, affecting the timing and development of naturally spawned eggs and fry in downstream reaches. Logging in the Cascade and Coast Ranges, and agriculture, urbanization, and gravel mining on valley floors have contributed to increased erosion and sediment loads.

The effect of these changes as a whole is that critical habitat is not able to fully serve its conservation role in many of the designated watersheds. Factors limiting the functioning of PBFs and thus the conservation value of critical habitat for UWR steelhead within the action area are discussed in more detail in the Environmental Baseline section, below.

2.14.1.3 Climate Change Implications for UWR Steelhead and Critical Habitat

One factor affecting the rangewide status of UWR steelhead and aquatic habitat is climate change. The USGCRP[432] reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The 5 warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007), characterized by the ISAB[433] as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.

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[432] http://www.globalchange.gov

[433] The ISAB serves NMFS, Columbia River Indian Tribes, and the Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

- With a smaller snowpack, watershed runoff will decrease earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

Likely changes in temperature, precipitation, and wind patterns (as well as sea-level rise in the lower estuary) have implications for survival and recovery of UWR steelhead in both their freshwater, estuarine, and marine habitats and the PBFs of their critical habitat. While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (ISAB 2007). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1 to 4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure, and coastal wetlands, and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

Climate change would affect UWR steelhead in the following ways: 1) warmer stream temperatures could cause changes in growth and development rates and disease resistance, 2) changes in flow regimes (larger winter floods and lower flows in the summer and fall) could reduce egg and juvenile survival, and alter outmigration and spawning run timing, and 3) changing ocean conditions and marine food webs could affect ocean survival and growth.

Crozier et al. (2019) assessed UWR steelhead as having a high vulnerability to the effects of climate change based on an analysis of the DPS's sensitivity (high) and exposure (high). Further, the species was determined to have a moderate adaptive capacity. The moderate score for adaptive capacity reflected in the conclusion is based on the following analysis. Winter steelhead in the upper Willamette River have an extended freshwater residency, and the majority of naturally produced smolts migrate during their second spring (Keefer and Caudil 2010). Although it is possible for winter steelhead to complete the life cycle as resident *O. mykiss*, there is little information on the frequency of this life-history trajectory, and it is not thought to be common among naturally produced fish. While juvenile winter steelhead will redistribute themselves during freshwater residency, cooler, higher-elevation rearing habitat is not present in tributary basins (Molalla and Calapooia Rivers), inaccessible due to impassable dams (North Santiam, Brietenbush, and Middle Santiam Rivers), or severely degraded (South Santiam River). There is considerable flexibility in juvenile migration timing (Keefer and Caudill 2010) and adult return timing (Naughton et al. 2015) to adapt to changing temperature extremes. There has been no hatchery supplementation of winter run steelhead since the late 1990s, and, with the exception of hybridization with non-native summer-run and early-winter run steelhead, the genetic integrity of this DPS is thought to be relatively intact (Van Doornik et al. 2015, NMFS 2019f).[434]

One of the most important factors driving sensitivity of UWR steelhead was hatchery influence, which was ranked high. Though hatchery propagation of this lineage is no longer occurring, there are established populations of nonnative winter-run steelhead, active hatchery summer-run steelhead production, and feral natural production of non-native summer- and winter-run steelhead in the basin (Busby et al. 1996, Van Doornik et al. 2015, NMFS 2019f). There is also a potential legacy of stocking non-native hatchery rainbow trout to support recreational harvest in reservoirs and rivers.

The most important freshwater exposure factor was stream temperature, which is important because steelhead juveniles generally rear for 1 or more years in fresh water before migrating (Busby et al. 1996). Of the four recognized populations of winter steelhead in the UWR Basin (Myers et al. 2006), all drain the west slope of the Cascade Range, but only the North Santiam River extends in the high Cascades region where snow melt and groundwater contribute significantly to stream flows (Chang et al. 2018). Access to much of the higher elevation historical spawning habitat in the North Santiam is blocked by impassable dams (NWFSC 2015). In studies of steelhead in other basins, warmer summer temperatures are associated with development of anadromy, whereas a resident life-history was more prevalent in streams with colder summer water temperatures (McMillan et al. 2012). In contrast, the distribution of native steelhead in the upper Willamette River basin is not clearly associated with gradients in summer stream temperatures.

In the Willamette River basin, native late-winter migrating populations occur in watersheds draining the Cascade Mountains on the eastern edge of the basin. Interestingly, native steelhead populations are not believed to occur in the upper extremes of the basin, nor in the tributaries on its western edge that drain the Coastal Range, though it is well known that steelhead migrate much longer distances to reach spawning grounds in other watersheds (Busby et al. 1996). In other systems, longer steelhead migrations are associated with much earlier (months earlier) timing of adult returns relative to the spring spawn timing of upper Willamette River steelhead. Thus, the late winter entry of Willamette River steelhead, which is believed to be an adaptation to allow historical passage over Willamette falls (Busby et al. 1996), may pose a temporal constraint on the migration distance that native steelhead can attain prior to spawning. Such time constraints may be more important than temperature in terms of the distribution of steelhead in the Willamette River basin.

2.14.2 Environmental Baseline

The “environmental baseline” refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical

[434] For additional information, see https://www.fisheries.noaa.gov/data-tools/west-coast-salmon-vulnerability-species-specific-results.

habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For UWR steelhead, we focus the description of the environmental baseline on that portion of the action area where UWR steelhead juveniles and adults would be most exposed to the effects of the proposed action. Most juvenile and adult UWR steelhead migrate between spawning and rearing habitat in the Willamette River basin directly to the ocean via the lower Columbia River. To determine the upstream extent of UWR steelhead distribution and thus exposure to effects of the proposed action, we reviewed UWR steelhead PIT detections at Bonneville, The Dalles, and McNary Dams from 2013 through 2019. A total of four adults were detected at Bonneville Dam during this time, all in 2016 (Bellerud 2020), i.e., less than one adult per year. No detections were observed at The Dalles and McNary dams. Therefore, the area where UWR steelhead experience the effects of the proposed action is the Columbia River from the tailrace of Bonneville Dam to the plume,[435] including tributary confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions. It is likely that the small number of adults from this DPS that ascend Bonneville or other upstream dams fall back, through either the turbines or the spillbays or sluiceway (safer routes), to find their natal tributaries.

2.14.2.1 Mainstem Habitat

On the mainstem of the Columbia River, water storage projects (including the CRS and reservoirs in Canada operated under the Columbia River Treaty) and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013b). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range seasonally from lows of 71 to 106 kcfs to highs of 530 kcfs (Hamilton 1990, NMFS 1998, Prahl et al. 1998, USACE 1999). Naturally occurring maximum flows on the river occur in May and June as a result of snowmelt in the headwater regions. Naturally occurring minimum flows occur from

[435] The Columbia River plume is defined as the waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). However, once juvenile salmonids move away from the mouth of the Columbia River, they enter a region where physical and biological processes are dominated by coastal currents and water masses. For this reason, we consider the action area to include the Columbia River plume in the vicinity of the river mouth.

September to February. During the winter, periodic peaks in flow occur due to heavy rain events (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water management activities have reduced flows in the Columbia River, measured at Bonneville Dam, from April through July. On average, this reduction ranges from 7 kcfs in March to 171 kcfs in June (Figure 2.14-2). Proportional flow reductions occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River) and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River). Flow management for hydropower has increased flows measured at Bonneville Dam during winter months.

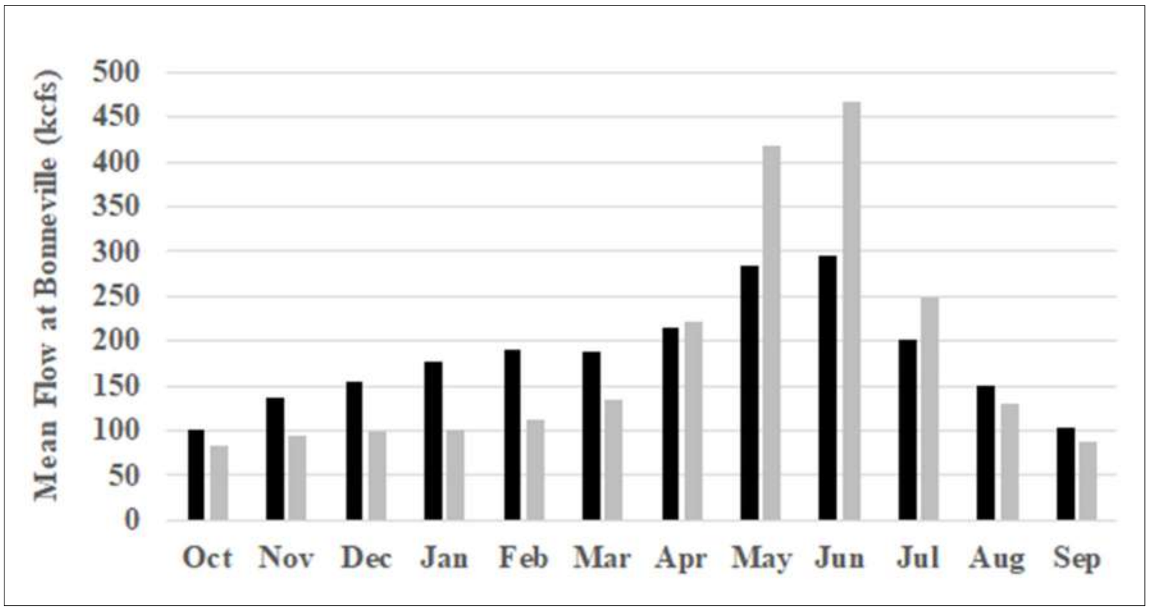

Figure 2.14-2. Simulated mean monthly flows for the Columbia River at Bonneville Dam under "current" (black) and "unregulated" (gray) conditions. "Current" flows were estimated using ResSim model simulations for the Columbia River System Operations EIS No Action Alternative. "Unregulated" flows are from the 2010 Level Modified Flows Streamflow dataset, which removes effects of the existence and operation of the CRS, Canadian dams, and non-federal dams in the US and Canada but includes Reclamation projects in the Upper Snake, Deschutes, and Yakima rivers.[436] These data show that current flows are lower during much of the spring outmigration period than they would be without the existence and operations of the CRS and other dams in the Columbia River basin.

The flow versus survival relationships for some interior basin ESUs/DPSs remain nearly constant over a wide range of flows but decline markedly as flows drop below a threshold (NMFS 1995a, 1998). As a result, NMFS and the Action Agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The

[436] The 2010 Level Modified Flows Streamflow data (available at https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Historical-Streamflow-Data.aspx) and ResSim model results for the No Action Alternative (monthly mean flows for period of record, WY1929-WY2008, deterministic ResSim modeling for Columbia River System Operations Draft EIS, February 28, 2020) were provided by Kristian Mickelsen, U.S. Army Corps of Engineers, on June 12, 2020 (Mickelsen 2020).

Action Agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows. These seasonal flow objectives have guided preseason reservoir planning and in-season flow management.

Despite management focused on meeting seasonal flow objectives, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been lower during May to July and higher in October to March. Even though several million acre-feet of stored water is released each summer to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not fully offset the volume consumed in the basin in July and August (BPA et al. 2020). Reduced spring and summer flows have increased travel times during outmigration for juvenile salmonids and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July.

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). In a more recent study, Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50 percent (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

2.14.2.2 Passage Survival

With the exception of an extremely limited number of adult strays detected at Bonneville Dam, none of the populations in this DPS pass any of the mainstem CRS projects.

2.14.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread

presence of PCBs and PAHs, both geographically and in the food web. Water quality and salmon samples from locations downstream of the lower river's major population and industrial centers showed higher concentrations of toxic contaminants than samples from upstream locations, suggesting that much of the contaminant load seen in juvenile salmon is coming from their time spent rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area, including the superfund-designated reach in the lower Willamette River. Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Under these environmental conditions, fish in the action area are stressed. While the magnitude of effects to juvenile or adult UWR steelhead is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of UWR steelhead, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

The impact of water temperatures in the Columbia River on salmon and steelhead survival is a concern; because of temperature standard exceedances, portions of the lower Columbia River are on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.

- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures).
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging.
- Point-source discharges such as cities and industries.
- Climate change.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960 to 1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced.
- Water temperature variability has decreased.
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the lower Columbia River likely have similar effects.

These hydrosystem effects, which stem from both upstream storage projects and run-of-river mainstem projects, continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the lower Columbia River during spring, but summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem.

In May, 2020, EPA issued a draft TMDL for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River (EPA 2020). As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas of cold water refugia are important to summer migrating salmonids. EPA is accepting public comment on their draft TMDL until July, 2020, and will subsequently issue a final TMDL.

The states of Oregon and Washington have completed their approval of allowing juvenile fish passage spill up to 125 percent TDG in the spring and up to 120 percent TDG in the summer as monitored in the tailrace of the four lower Columbia River and four lower Snake River dams. Both states require GBT monitoring for both salmonid and non-salmonid native fish to be able to spill up to 125 percent TDG in the spring. If GBT levels exceed state water quality agency thresholds, then spill must be reduced in accordance with state implementation guidance. The Oregon Environmental Quality Commission approved the Order Approving a Modification to Oregon's Water Quality Standard for Total Dissolved Gas in the Columbia River Mainstem at its January, 24, 2020, meeting. The order was signed on February 11, 2020, by the ODEQ director. On July 31, 2019, Ecology proposed amendments to Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO #19-02). On December 30, 2019, Ecology adopted the final rule amendments. EPA approved the rule on March 5, 2020. The amendments adopted into rule include the numeric criteria for TDG in the Snake and Columbia Rivers at WAC 173-201A-200(1)(f)(ii). Ecology's TDG Rule Implementation Plan can be found in Chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (WDOE publication number: 19-10-048. December, 2019).

2.14.2.4 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead, and could result in exposure to toxic compounds, behavioral avoidance of contaminated water or sediments, or even, in some circumstances, death. The extent to which leaked grease or oil, occurring in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of UWR steelhead in the past is unknown. Small leaks into the large volumes of flowing water around projects would be difficult to detect and quantify, and even more difficult to detect downstream, near and below the confluence of the Willamette River where most UWR steelhead would be exposed. Any effects of past leakages on survival would be reflected in annual juvenile or adult reach survival estimates.

Actions undertaken by the Corps since 2014 have reduced the potential for negative effects stemming from leaked grease or oil and thus have likely slightly improved the conditions for juvenile and adult migrants. The Corps implements a program of best management practices to avoid accidental releases of oil and grease and to minimize any adverse effects from equipment in contact with the water. Where feasible, the Corps uses greaseless equipment or environmentally acceptable lubricants. The Corps implements oil accountability plans[437] with enhanced inspection protocols and prepares annual oil accountability reports that record

[437] The Lower Columbia River and Lower Snake River projects are subject to the Northwestern Division Policy on Oil and Grease Accountability at Operating Projects (OGAP) in NWDR 1130-2-9 dated 13 July 2015.

quantities of oil and grease used at a project and subsequently removed from the project, and so any unaccounted "losses" of oil or grease are tracked.

EPA is proposing to issue NPDES permits to the Corps for the eight projects on the lower Snake and Columbia Rivers.[438] The draft permits do not address waters that flow over a spillway or pass through the turbines, as these are considered to be "pass through" waters and not regulated by NPDES permits. The draft permits do address the discharge of cooling water, equipment and floor drain water, equipment and facility maintenance-related water, and, at some projects (e.g., The Dalles and Bonneville Dams), backwash strainer water on cooling water intakes. Most discharges that affect water quality are ancillary to the direct process of generating electricity at a project, and rather result from oil spills, equipment leaks, or improper waste storage.

In response to the NPDES permit applications, EPA determined for each project the pollutants or parameters that are or may be discharged at a level that "will cause, have the reasonable potential to cause, or contribute to an excursion above any State or Tribal water quality standard." EPA accounted for existing controls on sources of pollution, the variability of the pollutant in the effluent, toxicity to aquatic life, and where appropriate, dilution in the receiving water (EPA 2018). As a result of their analysis, EPA determined that there exists a reasonable potential for discharges of oil and grease, and for exceedances of the pH standard.

"Oil and grease" in a regulatory sense is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil, and animal-derived fats. Oil and grease are not naturally occurring substances, and the toxicity varies among different types of oils and greases (EPA 2018). Fish may be exposed to oil and grease through their gills or through food. Toxic effects include delayed growth, decreased survival, and carcinogenic and mutagenic activity, and are particularly damaging when fish are exposed during early life stages (Perhar and Arhonditsis 2014).

pH is a measure of hydrogen ion activity and affects many biochemical processes in natural waters. The degree of dissociation of weak acids or bases is affected by pH, which in turn influences the toxicity of many compounds. The reproductive success of salmonids decreases at a pH of less than 6.5 or more than 9.2 (EPA 2018). Although EPA found no water quality impairments for pH at the projects in the lower Snake and Columbia Rivers, the draft NPDES permits propose pH limits to ensure that surface waters do not exceed an acceptable range.

The draft permits impose numeric effluent limitations for oil and grease (5 mg/L) and pH (6.5 to 8.5 standard units) and require monitoring and reporting for numerous other environmental parameters and potential pollutants (e.g., flow; temperature; toxics; total suspended solids; visible oil sheen; floating, suspended, or submerged matter; and oxygen-demanding materials).

[438] Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Snake River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-snake-river. Draft Discharge Permits for Federal Hydroelectric Projects in the Lower Columbia River, accessed on June 16, 2020 at https://www.epa.gov/npdes-permits/draft-discharge-permits-federal-hydroelectric-projects-lower-columbia-river

The draft permits require a BMP plan to prevent and minimize oil releases, oil accountability tracking, the use of environmentally acceptable lubricants unless technically infeasible, and use of technologies and operations that minimize the impingement and entrainment of fish in cooling water intake structures. EPA accepted public comments on draft permits for the eight projects from March 18 to May 4, 2020. If issued, the NPDES permits would allow the Corps to discharge oil and grease and pH in compliance with Section 402 of the Clean Water Act.

2.14.2.5 Tributary Habitat

Information about the species' status in the tributary portion of its life cycle and the status of its critical habitat can be found in Section 2.14.1. Tributary habitat occupied by UWR steelhead is not exposed to the effects of the proposed action.

2.14.2.6 Estuary Habitat

The Columbia River estuary provides important migration habitat for UWR steelhead populations. Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with hydrosystem flow regulation and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus that supports salmonid food webs (Simenstad et al. 1990, Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary such as those highlighted in the most recent 5-year review have improved connectivity to floodplain habitat (NMFS 2016e). From 2007 through 2019, restoration sponsors implemented 64 projects, including dike and levee breaching or lowering, tide gate removal, and tide gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis 2019, BPA et al. 2020). This represents a more than a 2.5 percent net increase in a connectivity index for floodplain wetland habitat (Johnson et al. 2018). Although yearling steelhead migrants are less likely to enter and rear in these areas, the large amounts of prey (particularly chironomid insects) exported from restored wetlands to the mainstem are actively consumed by these fish, especially natural-origin smolts. The resulting growth likely contributes to survival at ocean entry (PNNL and NMFS 2020). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

As discussed in Section 2.14.2.3 (Water Quality), habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005, LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, the levels in the estuary are much higher, as it receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, and they are widespread throughout the estuarine food web (Furher et al. 1996, Tetra Tech 1996, LCREP 2007). Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.14.2.7 Hatcheries

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect natural populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

Winter steelhead hatchery programs were terminated in the late 1990s. Currently, the only steelhead programs in the upper Willamette River basin release non-native summer steelhead. Annual total releases have been relatively stable at around 600,000 fish from 2009 to 2019, although the distribution has changed, with fewer fish being released in the North and South Santiam Rivers and corresponding increases in the McKenzie and Middle Fork Willamette Rivers to maintain the release level of about 600,000 fish.

There is some concern regarding the effect of introduced summer steelhead on native late-winter steelhead. While introgression of hatchery summer steelhead into winter steelhead populations has likely occurred, the degree to which it has occurred varies among populations. There is also uncertainty in classifying hybrids of summer and winter steelhead in the UWR. For example, Weigel et al. (2019) showed relatively high introgression of summer steelhead in areas where summer steelhead do not occur (the westside tributaries), raising questions about whether the assumptions used for identifying hybrid steelhead were correct. Other studies show strong relationships between steelhead genetics and aquatic habitat, even within steelhead populations of the Willamette/Lower Columbia River Domain (Van Doornik et al. 2015, NMFS 2019f).

The presence of hatchery-reared and feral hatchery-origin fish in the upper Willamette River basin may also affect the growth and survival of juvenile late-winter steelhead. In the North and South Santiam Rivers, juveniles are largely confined by dams below much of their historical spawning and rearing habitat. Releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter juvenile steelhead.

NMFS (2019f) recently completed a consultation on the effects of the Corps' hatchery programs for spring Chinook salmon, summer steelhead, and rainbow trout in the upper Willamette River basin. We described ongoing concerns about the genetic and ecological effects of the non-native summer steelhead hatchery program on listed species. Recent management changes have been implemented to reduce the straying of summer steelhead in the wild. The broodstock is also being managed for earlier spawning to reduce the risk of interbreeding with winter steelhead. Releases of summer steelhead in the North and South Santiam Rivers are at the lowest levels since at least the early 1980s.

2.14.2.8 Recent Ocean and Lower River Harvest

There is no directed fishery for winter steelhead in the ocean or lower Columbia River. There is some incidental mortality in the commercial net fisheries for hatchery Chinook salmon and steelhead in the lower Columbia River (total freshwater harvest is estimated to be about 9.5 percent of steelhead). Tribal fisheries occur above Bonneville Dam and do not impact UWR steelhead (NWFSC 2015).

2.14.2.9 Predation

2.14.2.9.1 Avian Predation

As noted above, dams and reservoirs around the Columbia River basin block sediment transport, and total sediment discharge into the river's estuary and plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including UWR steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island, where the tern diet would diversify to include marine forage fish. During 2001 to 2015, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island.

Evans and Payton (2020) have not estimated avian predation rates for UWR steelhead because few of these fish are PIT tagged. The average annual predation rates by East Sand Island terns on

LCR steelhead may be an adequate surrogate for predation rates on smolts from the UWR steelhead DPS, 15.2 percent per year before the management plan was implemented, and 10.4 percent post-management (Evans and Payton 2020) (Appendix B). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019).

Before the management plan for double-crested cormorants was first implemented, the vast majority of those in the Columbia River estuary nested on East Sand Island. We do not have species-specific estimates of predation rates on UWR steelhead, but the average annual predation rate at this colony on LCR steelhead, pre-management, was 5.4 percent per year. Starting in 2016, however, cormorants did not establish a nesting colony throughout the entire peak of the smolt outmigration period (April to June). Instead, large numbers of birds dispersed from East Sand Island to other locations, especially the Astoria-Megler Bridge,[439] where smolts are likely to constitute a larger proportion of the diet. The average annual predation rates on LCR steelhead, used here as a surrogate for effects on UWR steelhead, for the two post-management periods (5.0 percent in 2015 to 2017 and 0.6 percent in 2018) (Evans and Payton 2020) therefore cannot be directly compared to those before management began, and are likely to underestimate predation rates in the estuary.

Compensatory Mortality and Avian Predation Management

Evaluating the effectiveness of a predator control program is a two-step process: 1) estimate the magnitude of predation on a focal species, and 2) estimate the effectiveness of the control method (ISAB 2019). We discuss the first step in the preceding sections, reporting the percent change in average annual predation rates on UWR steelhead after reducing numbers of terns and cormorants at East Sand Island and elsewhere in the Columbia River basin. To evaluate the effectiveness of these control programs, we must then consider whether any gain in numbers of smolts overestimates the conservation benefit in terms of adult returns because of either compensatory behavior of the prey (e.g., density dependence) or of another predator (e.g., removing one predator species may increase predation by another).

Compensatory effects are difficult to quantify because they occur later in the life cycle and often vary within and between years. As discussed in Appendix B, there are now two distinct modeling frameworks that try to detect whether avian predation in the Columbia River basin is an additive versus compensatory source of mortality. Haeseker et al. (2020) looked for correlations between predation rates by terns and cormorants on East Sand Island and adult returns for SRB steelhead; and Payton et al. (2020) used a joint mortality and survival model to examine effects of tern predation at sites across the Columbia River basin on adult returns for UCR steelhead. The two

[439] The number of cormorants nesting on the Astoria-Megler Bridge has continued to grow so that an estimated 5,408 nesting pairs (3,672 on East Sand Island and 1,736 on the Astoria-Megler Bridge) (Turecek et al. 2019) were in the lower estuary in 2018. Hundreds more double-crested cormorants have been observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA 2017). Smolts may constitute a larger portion of the diet of cormorants nesting at these sites than if birds were foraging from East Sand Island.

modeling frameworks used different but related data sets and came to very different conclusions. Haeseker et al. (2020) found that predation by terns on East Sand Island was completely compensatory (i.e., had no effect on adult returns). Payton et al. (2020) found that higher probabilities of Caspian tern predation were associated with lower probabilities of SARs in all years studied. These differences indicate the need for further regional review (Appendix B; see also Skiles 2020).

For the purpose of determining whether implementation of the avian predation management plans has been effective, NMFS' position is that avian predation is likely to be partially compensatory, with the degree of compensation varying between years as described in Payton et al. (2020). That is, the higher the predation rate before colony management and the greater the reduction after measures are in place, the higher the likelihood that we are able to influence adult returns (an additive effect). But the ocean conditions that outmigrants experience, such as the number and behavior of predators and competition for prey, which can trigger compensatory effects, will also be important.[440]

With respect to managing terns in the estuary, using predation rates on LCR steelhead as a surrogate for those on UWR steelhead, Caspian terns nesting on East Sand Island were eating an annual average of 15.2 percent of juvenile LCR steelhead outmigrants before management actions reduced the size of that colony, and 10.4 percent per year thereafter (Evans and Payton 2020). Considering the magnitude of predation rates before colony management (15.2 percent), the average 4.8 percent per year decrease achieved by reducing the size of the tern colony, and that some level of compensation is likely to have occurred in the ocean even in favorable ocean years, this management measure may not have led to increased adult returns for LCR steelhead or UWR steelhead. For double-crested cormorants, reduction of the colony area on East Sand Island plus hazing, egg take, and culling have reduced average annual predation rates on LCR steelhead, again used as a surrogate for UWR steelhead, from 5.4 percent to less than 1 percent. However, in this case, smolt predation rates are likely to have increased because thousands of birds are now foraging from the Astoria-Megler Bridge where they are farther from the marine forage fish prey base.[441]

2.14.2.9.2 Fish Predation

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow

[440] For example, Figure 4 in Payton et al. (2020) shows that Caspian tern predation on UCR steelhead was almost entirely compensatory during the unfavorable ocean conditions of 2015, but was relatively additive in the cold ocean year, 2008.

[441] The build-up of numbers of double-crested cormorants on the bridge has overlapped in time with increased predation pressure on East Sand Island cormorants by bald eagles (Appendix B) and cannot be attributed to the management measures alone.

predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The NPMP's Sport Reward Fishery removed an average of 188,708 piscivorous pikeminnow (> 228 mm fork length) per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winther et al. 2019). Sport Reward Fishery harvest from the area below Bonneville Dam accounted for 62 percent of total fishery removals in 2019 (among all locations from the estuary to Lower Granite reservoir), and 54 percent in 2018, and has been the highest-producing zone for all but one season since system-wide implementation began in 1991 (Williams et al. 2018, Winther et al. 2019). In the 2018 and 2019 Sport Reward Fishery, the second highest pikeminnow catch (removal) location was Bonneville Reservoir (17.4 percent in 2018 and 15 percent in 2019). On average, 16 adult steelhead and 198 juveniles were killed and/or handled each year in the Sport Reward Fishery during 2014 through 2018. The fishery is conducted over a much larger area than that occupied by UWR steelhead, but small numbers of these fish could have been from this DPS.

Juvenile salmonids are also consumed by nonnative fishes, including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids. Removing these fish in the lower Columbia River may incrementally improve juvenile steelhead survival.

2.14.2.9.3 Pinniped Predation

California sea lions and Steller sea lions prey on adult steelhead throughout the lower Columbia River. The population size of California sea lions has shown a steady increase from lows in the mid-1970s to levels in 2014 above maximum net productivity level (Lakke et al. 2018). Recent declines in pup production and survival suggest that the population may have stopped growing. This vulnerability is primarily for spring-run populations such as those from the UWR steelhead DPS, which migrate during spring, when the pinnipeds' abundance is highest. Through an authorization under the MMPA, management agencies have implemented numerous measures to reduce predation at Willamette Falls, Bonneville Dam, and Astoria. In 2019, the State of Oregon lethally removed 33 individually identifiable predatory California sea lions that were having a significant negative impact on ESA-listed salmonids at Willamette Falls (ODFW 2019a). The states are authorized under Section 120 of the MMPA to remove California sea lions at Bonneville Dam until June 2021, and at Willamette Falls until November 2023. This authorization does not allow the removal of Steller sea lions. The Endangered Salmon Predation Prevention Act was signed into law in December of 2018. The new law reduces restrictions for removing predatory sea lions by superseding the individually identifiable and significant negative impact criteria and allows for the lethal removal of predatory California and Steller sea lions in the Columbia River and tributaries. On June 13, 2019, NMFS received and is currently reviewing applications from the states and tribes requesting Section 120(f) authorization to intentionally take, by lethal methods, sea lions that are located in the main stem of the Columbia River between RM112 and McNary Dam (RM292), or in any tributary to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead (84 FR 45730).

2.14.2.10 Research, Monitoring, and Evaluation Activities

The primary effects of past and present CRS-related RME programs on UWR steelhead are those associated with the capturing and handling of fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status and trend monitoring; action compliance, implementation, and effectiveness monitoring; research; and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action.

Capturing, handling, and releasing fish can lead to stress and other sublethal effects, and fish sometimes die from such activities. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Certain RME methods also involve unavoidable but necessary lethal sampling of fish.

The NPMP has been operating annually since 1990 as a means of benefitting ESA-listed salmonids throughout the hydrosystem via predator (pikeminnow) removal. The program includes multiple RME components with sampling methods which can have a negative effect on ESA-listed salmonids, though the size of the effect is indeterminable due to the nature of the method (boat electrofishing) being used. The NPMP's RME strategy is two-pronged: 1) tagging pikeminnow for the Sport Reward Fishery to increase angler participation and thus, pikeminnow removals, and also to estimate overall population exploitation rates; and 2) collecting biological data from pikeminnow, smallmouth bass and walleye throughout the system to evaluate program effectiveness and evidence for any compensatory response. In recent years, these tagging and sampling efforts via boat electrofishing have occurred in the Columbia River from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conduct four, 15-minute sampling (i.e., electrofishing) events in shallow water per 0.6-mile reach during April through July. Most sampling occurs in darkness (1800 to 0500 hours), and sometimes under highly turbid river conditions.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Operators shut off the electrical field immediately upon observation of any salmonids, but due to the sampling conditions mentioned above, and because most stunned fish quickly recover and swim away, the take cannot be accurately observed, and the affected fish that are observed cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013 to 2017 electrofishing operations based on visual estimation methods. In 2019, an estimated 770 adults and 75,820 juvenile salmonids were encountered by these same electrofishing operations (Barr 2019). It is likely that some of these were UWR steelhead. While the aforementioned negative effects of this large-scale electrofishing effort can only be coarsely evaluated, it appears that the

NPMP in its entirety is likely to benefit the UWR steelhead DPS by reducing predation throughout the Columbia River migration corridor.

For all other CRS-related RME activities, we estimated the number of UWR steelhead that have been handled (or have died) each year during the implementation of RME as the average annual take reported for 2016 to 2019. To estimate effects of current RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

- No UWR steelhead were handled by activities associated with the Smolt Monitoring Program or the CSS.
- Only one natural-origin juvenile UWR steelhead was handled by activities associated with all other RME programs.

The combined take (i.e., handling, injury, and incidental mortality) of UWR steelhead associated with these elements of the RME program has, on average, affected nearly 0 percent of the natural-origin adult run and 0 percent of the naturally produced juveniles (Thompson 2020). The RME program (specifically trapping, handling, and tagging activities) increases stress for individual fish, which can negatively affect their fitness (probability of survival to a later life stage), and results in a small number of mortalities, and therefore negatively affects UWR steelhead.

Taken altogether, the effects of RME projects on overall adult and juvenile survival (estimated mortality) are relatively small (far less than 1 percent at the DPS level); the effects on fitness, while unquantifiable, are likely more substantial. Still, these programs provide information important for decision making and for assessing the efficacy of management actions which are key components of effective adaptive management programs.

2.14.2.11 Critical Habitat

The condition of UWR steelhead critical habitat in the action area, without the consequences caused by the proposed action, is reflected in the impacts on the physical and biological features essential for conservation discussed above and summarized in Table 2.14-2. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (i.e., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for UWR steelhead production have been weakened. Conditions in the portion of the lower Columbia River rearing habitat and migration corridor designated as critical habitat (i.e., the mainstem of the Columbia River below the confluence of the Willamette River) were substantially affected by the development and operations of upstream storage reservoirs and the principal effect on the migration corridor PBF is altered mainstem flows. As described in the preceding sections, measures taken by the Action Agencies and other regional parties in the decades since critical habitat was designated for UWR steelhead have improved the functioning of PBFs, although more improvement will be needed before many areas function at a level that supports recovery.

Table 2.14-2. Physical and biological features (PBFs) of designated critical habitat for UWR steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater spawning	Substrate, adequate water quality and water quantity.	Freshwater spawning sites used by UWR steelhead are in tributaries to the Willamette River and are not within the action area for this consultation. The Willamette Project flood control/water supply/hydropower dams obstruct access to spawning habitat in the four historically most-productive tributaries to the Willamette River and reduced water quality and quantity in the remaining areas downstream. Land use practices including urban development, agriculture, timber harvest, mining and grazing, and bank hardening have obstructed access to historically productive spawning habitats and reduced water quality, water quantity, and substrate (spawning gravels) in the remaining areas.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality, forage, and natural cover.	Much of the freshwater rearing habitat used by UWR steelhead is in tributaries to the Willamette River and is not within the action area for this consultation. The Willamette Project flood control/water supply/hydropower dams obstruct access to rearing habitat in the four historically most-productive tributaries to the Willamette River and reduced water quality and quantity in the remaining areas downstream. Land use practices including urban development, agriculture, timber harvest, mining and grazing, and bank hardening have obstructed access to historically productive rearing habitats and reduced water quality, water quantity, and substrate (spawning gravels) in the remaining areas. See also “estuarine areas.”

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover.	Alteration of the seasonal flow regime in the lower Columbia River with elevated fall and winter and reduced spring flows (hydrosystem development and operation). Reservoir releases are managed to seasonal flow objectives for juvenile fish survival given the amount of runoff expected in a given year. Given the Action Agencies' ability to meet the spring flow objectives in the last 20 years, this change in the seasonal hydrograph had a small negative effect on water quantity in the juvenile migration corridor in average to high flow years and a moderate negative effect in lower flow years for all populations. Alteration of the seasonal mainstem temperature regime in the lower Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring when juvenile UWR steelhead are migrating and warmer temperatures in the late summer and fall, compared to historical conditions (hydrosystem development and operations).[1] Adult UWR steelhead enter the lower Columbia River during winter and are not affected by a seasonal temperature shift. Reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (hydrosystem development) may have reduced "natural cover" in the migration corridor. Reduced water quality due to presence of chemical contaminants and excessive nutrients that lead to low dissolved oxygen concentrations (municipal, agricultural, industrial, and urban land uses and other activities such as mining) affects all populations.
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, juvenile and adult forage.	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects), have reduced access to floodplain habitat for rearing and prey production and the quantity and quality of estuarine rearing areas. Restoration actions by the Action Agencies and other regional parties have increased connectivity of habitats that produce prey for yearling steelhead by more than 2.5 percent. Another 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. Increased opportunities for avian predators (construction of dredge-material islands in the lower river and other human-built structures such as bridges and navigation aids used by terns and cormorants for nesting) have created excessive predation. Implementation of the

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors Affecting Condition of the PBF
		Caspian Tern and Double-crested Cormorant management plans for the colonies on East Sand Island may not have reduced predation rates on juveniles from this DPS. Predation rates for birds foraging from the Astoria-Megler Bridge are likely to be even higher than for cormorants foraging from East Sand Island. Observations of increased pinniped predation and risk for spring migrating adult Chinook salmon in the lower Willamette and Columbia Rivers.
Nearshore marine areas[2]	Free of obstruction and excessive predation with water quality, quantity, and forage.	Concerns about increased pinniped predation and adequate forage. Reduced quality of nearshore marine areas.

[1] The magnitude and timing of temperature shifts in a given year compared to pre-dam conditions depends on flow and air temperatures; when spring and summer flows are low, high air temperatures have caused water temperatures to increase substantially as early as June or July.

[2] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.14.2.12 Anticipated Impacts of Completed Consultations

The environmental baseline includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of UWR steelhead, including recent biological opinions issued for UWR steelhead and key emergent or ongoing habitat concerns (NMFS 2016e). From January 2015 through May 22, 2020, we completed 460 formal consultations that addressed effects to UWR steelhead.[442] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Another example of a large consultation is NMFS' 2008 biological opinion on the operations and maintenance actions (including adjustments to the timing of flow augmentation from the upper Snake River projects to better meet the needs of listed fish) of Reclamation's upper Snake River projects. The effects of the upper Snake River projects (e.g., water diversion, consumptive loss, and return flows) are incorporated into the data used to model flow effects in the mainstem Snake and Columbia rivers in this opinion (BPA et al. 2020). UWR steelhead are exposed to the effects of this 2008 action when they are migrating

[442] PCTS data query, July 31, 2018; ECO data query May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

through the lower Columbia River downstream from Portland. Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat, improve riparian condition outside of the action area, and increase channel complexity and instream flows throughout the Columbia River basin. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 23 projects in the Columbia River basin that improved fish passage in 2018 (the last year for which data are available), and 118 projects that involved river, stream, floodplain, and wetland restoration; some of these projects are likely to benefit UWR steelhead. These projects will benefit the viability of the affected populations by improving habitat function and population abundance, productivity, and spatial structure. Some of these projects, especially projects in the estuary, are likely to provide beneficial effects for UWR steelhead. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPAs were found to meet the ESA standards for avoiding jeopardy and destruction or adverse modification.

Similarly, future Federal restoration projects that have undergone consultation will improve the functioning of some of the PBFs of critical habitat (e.g., obstructions in migration corridors, gravel in spawning sites, and water quantity and quality in spawning and rearing sites and in migration corridors). Any short-term adverse effects that occur during project implementation were addressed in the consultations.

2.14.2.13 Summary

Altogether, the stressors described above for each life stage of UWR steelhead are expected to continue. The status of the species is continuing to decline, even with management reforms. Although certain structural improvements have been implemented at the Willamette Project dams, such as those at the collection facilities, the loss of habitat historically available for most populations above those dams continues to be a primary limiting factor/threat. For UWR steelhead residing below these dams, pre-spawning mortality rates are high and habitat quantity and quality issues persist. Low numbers of natural-origin steelhead coupled with high numbers of hatchery-origin steelhead result in a high proportion of hatchery-origin fish on the spawning grounds. The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of UWR steelhead populations. The small net improvement in floodplain connectivity achieved through the CRS estuary habitat program and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors (past land development, habitat degradation, and predation, in combination with the potential effects of climate change) (NMFS 2016e) will continue to negatively affect UWR steelhead .

Likewise, the habitat within the action area does not fully support the conservation value of designated critical habitat for UWR steelhead, as described above. The PBFs essential for the conservation of this species that occur within the area affected by the proposed action include freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River). The Action Agencies and other Federal and non-Federal entities have taken actions in the last two decades to improve the functioning of some of the PBFs of critical habitat. For juvenile steelhead, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. However, the factors described above will continue to have negative effects on these PBFs.

2.14.3 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. In our analysis, which describes the effects of the proposed action, we considered the provisions in 50 CFR 402.17(a) and (b).

The proposed action includes coordinated, basinwide water management activities to meet authorized project purposes (e.g., flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply) and to support the reliability of the federal transmission system; system operations (including operations for fish passage at mainstem Snake and Columbia River dams); maintenance; structural measures to benefit Pacific lamprey; non-operational conservation measures to benefit ESA-listed species (e.g., predation management, and tributary and estuary habitat improvement actions); and monitoring, reporting, and regional coordination (BPA et al. 2020, Section 2).

2.14.3.1 Effects to Species

The proposed action will implement flexible spill operations at the lower Snake River and lower Columbia River mainstem dams in an attempt to improve the survival of spring-migrating juvenile salmon and steelhead through the dams and improve adult returns.[443] Spring spill operations will occur from April 10 to June 15 at the four lower Columbia River projects. Beginning in the spring of 2021, McNary Dam will operate up to 125 percent TDG gas cap spill for a minimum of 16 hours per day, and may operate under "performance standard spill" for up to 8 hours per day. John Day Dam will spill up to120 percent TDG gas cap spill for 16 hours per day with 32 percent spill occurring during 8 hours of performance standard spill. The Dalles Dam will operate at 40 percent spill. Bonneville Dam will spill up to 125 percent TDG (with a

[443] Implementation of fish passage operations, including spring and summer spill operations, will occur adaptively and be specified in the annual Water Management Plan and Fish Passage Plan (including all appendices).

150 kcfs spill constraint) and 8 hours of performance standard spill at 100 kcfs. Typically, the 8 hours of performance standard spill may be split into two separate blocks, with one beginning in the AM hours, and one in the PM hours.

No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in the Fish Passage Plan unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of the Fish Passage Plan). Performance standard spill shall not be implemented between 2200 and 0300 hours. The higher powerhouse flow in these periods better aligns with regional energy demands and allows the Action Agencies greater power marketing flexibility, but also can alleviate passage delays for adults at some projects under the higher spill levels. The gas cap spill periods are intended to increase spillway passage, reduce travel time, and reduce powerhouse encounter rates for juvenile spring migrants. Daily spill caps to meet the tailrace TDG target at each project will be coordinated with NMFS and adjusted daily as necessary. Target spill levels with exceptions at each project are defined in Table 2.14-3.

Table 2.14-3. Spring spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Flexible Spill (16 hours per day)[1, 2, 3]	Performance Standard Spill (8 hours per day)[2, 4]
McNary	125% Gas Cap	48%
John Day	120% TDG target	32%
The Dalles[5]	40% (no flexible spill, performance standard spill 24 hours per day)	
Bonneville[6]	125% Gas Cap	100 kcfs

[1] Attempts should be made to minimize in-season changes to the proposed operations; however, if serious deleterious impacts are observed, existing adaptive management processes may be employed to help address issues that may arise in season as a result of implementing these proposed spill operations.

[2] Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability. To comply with state water quality standards, spill may be also reduced if observed GBT levels exceed those identified in state water quality standards (see Washington Administrative Code §173-201A-200(l)(f))).

[3] 125 percent gas cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws. This includes a criterion for not exceeding 126 percent TDG for the average of the two greatest hourly values within a day.

[4] The 8 hours of performance standard spill may occur with some flexibility. Other than at The Dalles Dam, performance standard spill will occur in either a single 8-hour block or up to two separate blocks per calendar day. No more than 5 hours of performance standard spill may occur between sunset and sunrise, as defined in Fish Passage Plan Table BON-5. Performance standard spill shall not be implemented between 2200 and 0300. No ponding above current MOP assumptions.

[5] Fish passage spill at The Dalles should be limited to spillbays 1 to 8 unless river flow exceeds 350 kcfs—then spill outside the spillwall is permitted. TDG levels in The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream projects or reducing spill below 40 percent at The Dalles.

[6] Fish passage spill at Bonneville Dam should not exceed 150 kcfs due to erosion concerns.

Summer spill operations will occur June 16 to August 31 at the four lower Columbia River projects. Summer spill will occur 24 hours each day. Summer spill will be divided into two periods: an initial period occurring from the end of spring spill until August 14, and a later period from August 15 to August 31 (BPA et al. 2020). Target summer spill levels at each project are defined in Table 2.14-4. Spill levels from June 16 to August 14 are consistent with recent performance spill levels. Spill levels will be reduced from August 15 to 31, when few juveniles are migrating in the lower Columbia River. The Action Agencies propose these late-summer reductions in spill to offset power system impacts caused by higher spring spill.

Table 2.14-4. Proposed summer spill operations at lower Columbia River dams as described in the proposed action (BPA et al. 2020).

Project	Initial Summer Spill Operation[1] (June 16 or 21 to August 14)	Late Summer Transition Spill Operation[1] (August 15 to August 31)
McNary	57% (with no spillway weirs)	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs[2]

[1] Spill may be temporarily reduced below the FOP target summer spill level at any project if necessary to ensure navigation safety or transmission reliability, or to avoid exceeding State TDG standards.

[2] This does not include 5 kcfs passing the project via the Bonneville Powerhouse 2 corner collector.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations of the hydrograph caused by CRS operations (generally increased flows from October through March; decreased flows from May through August, and little change in flows in April and September) described in the environmental baseline will continue to affect the mainstem migration and rearing corridor, estuary, and plume. The Action Agencies also propose three new water management operations:

- Basing the summer draft of Libby and Hungry Horse Reservoirs on the runoff volume estimates for those projects, instead of The Dalles runoff forecast, and adopting a sliding scale to determine the depth of the summer draft for these projects.
- Withdrawal of an additional 45,000 acre-feet annually from the Columbia River at the Grand Coulee project for irrigation needs.
- Potential drafting of Dworshak reservoir during high runoff years during the months of January to March for power generation, flood risk management, and avoidance of high levels of TDG in the Clearwater River in the later spring months.

The proposed changes in Libby and Hungry Horse Dam operations are intended to benefit resident species. The change in Libby Dam operations will cause the flow from this project to increase by 1 to 2 kcfs during the months of June to August in the lowest flow years and decrease by 1 to 2 kcfs in the highest flow years. The estimated combined effect from the proposed changes in project operations on flows in the lower Columbia River measured at McNary Dam will, on average, reduce flow by -1.2 kcfs during the month of April, -1.3 kcfs in May, -0.2 kcfs in June, -1.4 kcfs in July, and -0.9 kcfs in August (USACE et al. 2020).

The proposed operation at Dworshak Reservoir is intended to reduce winter spill events (and associated elevated TDG levels), which can create a hazard for incubating SR fall Chinook salmon in the lower Clearwater River and Clearwater River hatcheries when TDG is excessive. This operation may reduce spring flow in the lower Snake and lower Columbia Rivers by a small amount, due to the water being released during the winter months. However, the proposed operation is expected to occur in only the highest flow years.

The effects of CRS operations will include continued reduced flows in the lower Snake and Columbia Rivers during the months of May through July. The proposed changes in reservoir operations will affect monthly average outflows minimally (0 to 2 percent) at McNary Dam, relative to current conditions, with effects dependent upon season and water year (USACE et al. 2020). In average water years, monthly average McNary outflows will increase in January and February by 1 percent and will decrease in March, April, July, and August by less than 1 percent (in other months the changes in monthly average outflow, if any, will be less than 0.5 percent increase or decrease). In wet (1 percent exceedance) water years, McNary outflows will increase in January and February by 1 percent and will decrease in April, July, and September by 1 percent. In dry (99 percent exceedance) water years, McNary outflows will increase in October and February by 1 percent, will decrease in January, June, August and September by 1 percent, and will decrease in May by 2 percent (Figure 2.14-3).

Flow changes downstream of Grand Coulee will be within 2 percent of current conditions. Dworshak Dam will have a moderate increase in January outflow in wetter years, followed by minor decreases in February and March. Flows at the lower Snake and other lower Columbia River projects will not change substantially. In addition, forebay elevations at the lower Snake and lower Columbia River projects will not change substantially.

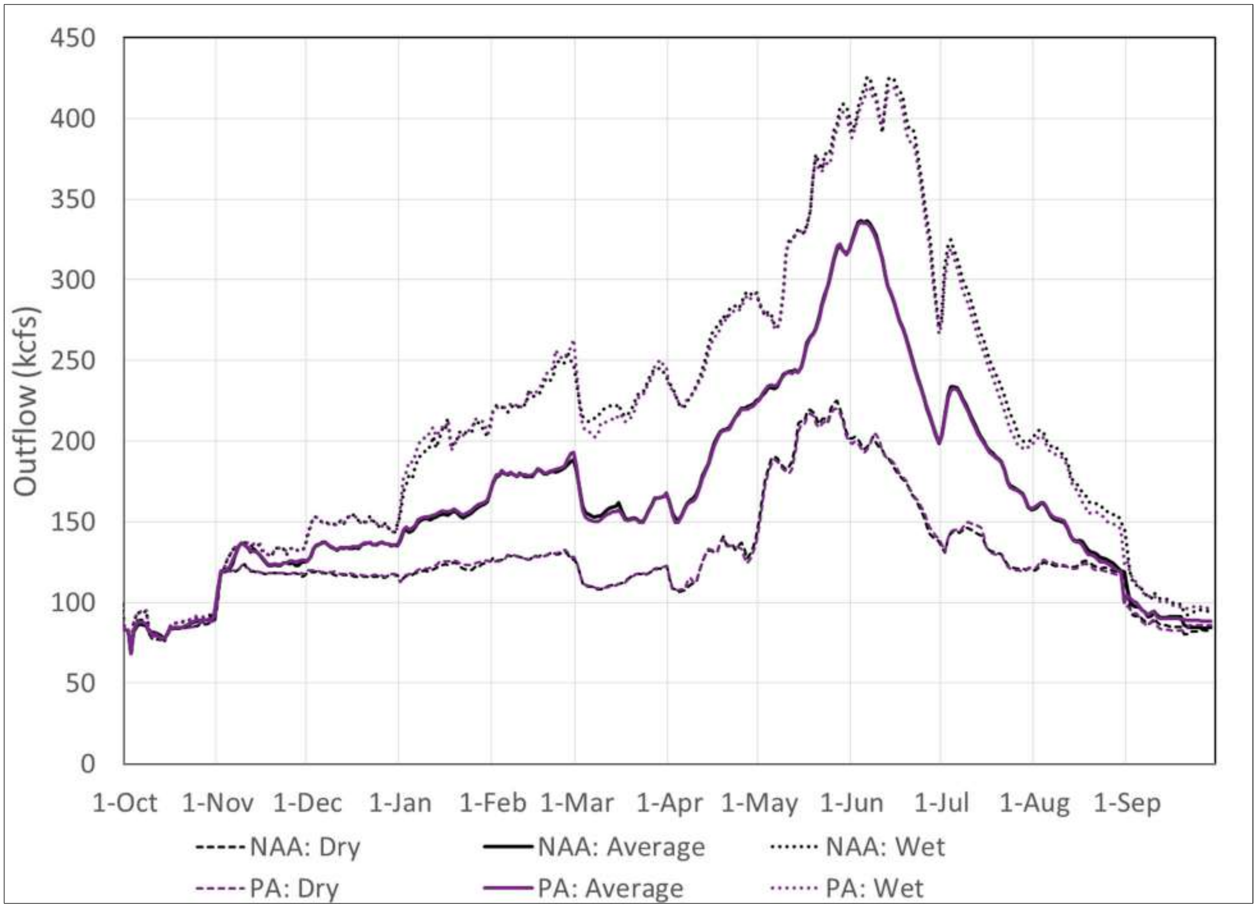

Figure 2.14-3. McNary Dam outflow modeled for the No Action Alternative (NAA) and Proposed Action (PA) during dry (99 percent exceedance), average (50 percent exceedance) and wet (1 percent exceedance) water years (USACE et al. 2020).

These proposed changes in reservoir operations are not likely to meaningfully affect the probability of meeting spring or summer flow objectives, and associated effects on UWR steelhead smolts or adults by a meaningful amount.

The Action Agencies propose to continue using best management practices to both account for and reduce and minimize the effects of oil and grease spills. The Corps will continue to implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The Corps' oil accountability reports from 2015 to 2019 for the eight projects on the lower Snake and Columbia Rivers document that discharges of oil and grease to the environment are infrequent and tend to be of small volume.[444] Across the five years of reporting at these eight projects, there were approximately 68 incidents of suspected or confirmed discharges of oil and grease to the environment. Among the 12 largest (10 gallons or greater) of these incidents, the estimated volume of oil and grease discharged to the environment ranged from 10 to 1000 gallons (mean 291 gallons). In most cases these larger discharges

[444] The Corps provides oil accountability reports for public review at https://www.nwd.usace.army.mil/Missions/Environmental/Oil-Accountability/.

occurred undetected at a slow rate over weeks or months. A majority of the discharges reported were observed oil sheens and, when a source was identified, resulted from leaks or spills that were estimated to be very small in volume (1 ounce to 1 gallon).

EPA reports that effluent concentrations are low for oil and grease at the lower Snake and Columbia River projects (EPA 2018); however, oil and grease are of concern because they are the primary pollutants introduced by facility operations. Low levels of oil pollution can reduce the reproductive success and survival of aquatic organisms (Perhar and Arhonditsis 2014, EPA 2018). Based on a review of applicable studies, EPA chose an aquatic life chronic exposure threshold of 0.050 mg/L for oil and grease, and a lethal exposure threshold of 0.3 to 0.6 mg/L for aquatic life at the lower Snake and Columbia River projects.

EPA analyzed effluent and river flow data for the lower Snake and Columbia River projects to determine the concentration of oil and grease that would occur below the mixing zones at each project, if all the projects simultaneously discharged oil and grease at the proposed permit maximum limit (5 mg/L) in low river flow conditions. EPA points out that this approach probably greatly overestimates the pollutant load coming from the outfalls, since it is unlikely that all projects would be discharging at the effluent limit at the same time. Under this scenario, the increase in oil and grease concentration between project inflow and river water downstream, after mixing (i.e., the increase in concentration due to the project), ranges from 0.00012 mg/L at McNary Dam to 0.025 mg/L at Lower Granite Dam. The EPA concluded that the expected oil and grease concentrations were below concentrations of concern.

The Corps' use of BMPs to avoid accidental releases of oil and grease and to minimize any adverse effects in case of accidental releases, enhanced inspection protocols, and annual oil accountability reporting should continue the slight, but positive, improvement in conditions for juvenile and adult migrants. Given the EPA's analysis supporting discharge limits for oil and grease at the lower Snake and Columbia River projects, the large flow volume of the lower Columbia River, the distances between the CRS projects and the Willamette River confluence, and the fact that few UWR steelhead adults have been observed moving upstream of Bonneville, any impacts of oil and grease on UWR steelhead are likely to be negligible.

The operation of the CRS will continue to affect sediment transport. By operationally reducing flows, less sediment is distributed, which increases water transparency, especially during the spring freshet. The increased water transparency hypothetically increases the exposure of UWR steelhead juveniles to predators and results in higher mortality rates than would be the case in a system with more normative flows.

Juvenile UWR steelhead spend less than a month in the estuary. Sediment delivery to the estuary will continue to be affected by the operation of the CRS. This decrease in sediment and associated organic material is expected to degrade estuarine wetland habitat and foodwebs; however, the magnitude of these effects and implications for juvenile salmonid foraging, growth, and survival have not been quantified (Bottom et al. 2005).

The effects of the proposed hydrosystem operations and the non-operational measures on UWR steelhead and its habitat are described below.

2.14.3.1.1 Hydrosystem Operation

For UWR steelhead, the effects of the proposed hydrosystem operations will generally be consistent with recent operations and mitigation measures with the addition of the proposed flexible spill operation. We assume that very small numbers of adults will pass over Bonneville Dam during implementation of the proposed action, comparable to the numbers reported for the last 10-year period (less than one PIT tagged fish per year). These will be lost from their respective spawning populations, but this is unlikely to affect the abundance or productivity of those populations.

During periods of increased spill each spring, elevated TDG levels will extend for at least 35 miles downstream of Bonneville Dam (Camas-Washougal gage). It is highly unlikely that UWR steelhead will be exposed to elevated TDG levels associated with the proposed increase in spring spill. A small number of adult UWR steelhead may be exposed to these conditions upstream of the mouth of the Willamette River. To the extent adult individuals stray and move further upstream in the Columbia River through Bonneville Dam, exposure to project effects will increase. There will be no exposure to elevated TDG levels associated with periods of increased spring spill levels for juveniles migrating and rearing in the Columbia River downstream of the Willamette River confluence because TDG effects will dissipate by the time the flows reach the Willamette confluence.

The effects of continuing the CRS operations will include greater than natural flows in the action area during the months of October through March, when UWR steelhead migrants are likely present in the Columbia mainstem and estuary. The continued changes in flow may alter the fitness of some individual fish (faster migration to the estuary), but we do not expect these changes to result in increased mortality for any populations. Similarly, UWR Chinook salmon will not be exposed to the changes in hydrosystem operations (increased spill, increased John Day Pool, transportation, reduced summer spill) and continued operations including maintenance operation of the facilities.

The proposed operations at Libby and Hungry Horse Dams should not have any substantial effect on Columbia River summer flow. The proposed operation at Grand Coulee Dam will have a very small effect on Columbia River flow, primarily during August, and should not affect juvenile migration or survival because these fish do not migrate in summer. The proposed operation at Dworshak Dam should not affect juvenile migration because any potential flow reduction would occur in high flow years and thus not add risk to juvenile migrants.

2.14.3.1.2 Predation Management and Monitoring Actions

The Action Agencies will continue to implement the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than 1 acre.

Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Active and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns and double-crested cormorants from nesting outside the managed areas. These ongoing actions will continue current levels of predation at this colony, but as discussed in the Environmental Baseline section, Evans and Payton (2020) have not estimated avian predation rates for UWR steelhead. Using estimates for LCR steelhead as a surrogate for UWR steelhead, implementation of the Caspian tern management plan could have reduced predation rates by about 5 percent. However, ocean conditions including compensatory effects such as the number and behavior of predators and competition for prey, will determine whether this reduction in tern predation influences adult returns. Although there appears to have been a small decrease in predation rates on LCR steelhead and by extension, UWR steelhead, large numbers of these birds are now foraging from the Astoria-Megler Bridge, where predation rates are likely to be higher. Thus, we expect that cormorant predation in the estuary may be an increasingly important source of mortality for UWR steelhead.

The Action Agencies will review the most recent monitoring and effectiveness information in the regionally sponsored avian predation synthesis report (to be completed in September 2020) and determine, in coordination with NMFS and USFWS, whether any additional management actions at Action Agency-managed lands in the estuary are warranted. However, we do not consider the effects of additional actions because none have been proposed at this time.

The NPMP's Sport Reward Fishery, or a similar removal strategy, will continue as part of the proposed action. This fishery removes approximately 10 to 20 percent of predatory-sized pikeminnow per year and is open from May through September. We estimate that the average number of steelhead, including some UWR steelhead, that will be handled and/or killed in the Sport Reward Fishery (or an alternative pikeminnow removal strategy), will be no more than 100 adults and 500 juveniles per year. These measures will continue to reduce predation rates in the river system as achieved under the 2008 RPA. Evidence of a compensatory response to pikeminnow removal still remains unclear; however, NPMP evaluation demonstrates that these programs are successful in restructuring the size distribution of the population of northern pikeminnow by reducing the number of larger, more predatory fish (Williams et al. 2018, Winther et al. 2019). A 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including UWR steelhead.

2.14.3.1.3 Habitat Actions

The tributary habitat improvements will not target any tributaries that provide habitat for UWR steelhead and, thus, will not affect this DPS.

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018, BPA and USACE 2019). This program's goals are to increase the extent and quality of estuarine ecosystems and improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) (PNNL and NMFS 2018, 2020) to UWR steelhead as they migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. The Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008 to 2019 (BPA et al. 2020), rather than to achieve a specific survival improvement. The Action Agencies note that because project cancellations and delays have sometimes occurred years into project development, there is uncertainty in forecasting exactly what restoration actions will be performed, and when. The Action Agencies therefore propose to include a "5-year rolling review," which will evaluate the acreage restored to date and projects available for the next 5-year period in their annual CEERP restoration and monitoring plan (e.g., BPA and USACE 2019). We acknowledge that there is uncertainty in predicting the timing and accomplishment of habitat restoration actions and find that, given the Action Agencies' recent record of completing 300 acres of floodplain restoration per year and their proposed intent to sustain this level of effort, this is an acceptable way of adjusting the program's annual goals over time.

The ERTG's (2019, 2020) landscape planning framework supports the choice of floodplain reconnection projects for the estuary habitat program. It gives the Action Agencies and their state, tribal, and non-governmental partner's guidance on the geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids. One consequence of this new guidance is that the Action Agencies have a scientific rationale for prioritizing smaller restoration sites that provide "stepping stones" at important transition points such as tributary confluences and hydrologic reach boundaries (ERTG 2020). Under the previous guidance for the program, the ERTG scoring process prioritized larger sites (typically 30 to 100 acres) because they were likely to provide greater ecological complexity and diversity at the local scale.

NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), is useful for prioritizing projects for implementation and for optimizing a project's design (e.g., numbers of breaches and channels) to site conditions. The ERTG's scoring system allows the Action Agencies to compare the potential benefits of a project to expected costs in a scientific and systematic manner. Project sponsors fill out the ERTG's project template, describing the certainty of success, certainty of habitat access, and certainty of benefit. The landscape planning framework adds questions to the template about potential benefits to juvenile salmonids from increased habitat opportunity along the length of the lower Columbia River (ERTG 2019).

The Action Agencies' proposal includes continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. Monitoring will continue at completed sites and initiated for sites constructed during the period of the proposed action. Johnson et al. (2018) found that the monitoring data collected since 2012 generally indicated that the restoration of physical and biological processes was underway. Continued implementation and evaluation of this monitoring program will either confirm that these floodplain reconnections are enhancing conditions for yearling salmonids, such as UWR steelhead as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate change science with the ERTG and regional partners in an effort to understand how their planned estuary projects can be more resilient to factors such as sea-level rise, increasing temperatures, and changes in seasonal mainstem flows. In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during the period covered by this consultation and beyond.

With all of these program elements in place (rolling 5-year reviews of project availability, landscape planning, the ERTG process for reviewing site designs, the monitoring program, and attention to climate change and adaptive management), NMFS expects that the Action Agencies' proposed implementation of the estuary program will continue to partially mitigate the effects of mainstem flow management which, combined with dikes and levees, has cut off much of the floodplain from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during the period of the proposed action, increasing the flux of insect and amphipod prey to the mainstem migration corridor for UWR steelhead. It is also reasonably certain that these benefits will increase as habitat quality matures, with the potential to contribute to increased abundance and productivity, and life-history diversity[445] of all UWR steelhead populations, although other factors (e.g., ocean conditions) will also influence these viability parameters and resulting trends.

2.14.3.1.4 Hatcheries

Nearly all of the hatchery programs funded by the Action Agencies for either conservation or mitigation for the impacts of the construction of the CRS have completed section 7 consultations

[445] The scientific literature includes extensive reviews discussing salmonid diversity, both within and among populations, summarized in McElhany et al. (2000). Juvenile behavior, one of the traits that exhibits considerable diversity, can be genetically based or vary with a combination of genetic and environmental factors. The more diverse a population's juvenile behavior, the more likely it is that some individuals will survive to reproductive age in the face of environmental change. By reconnecting large areas of the estuary floodplain, the Action Agencies give larger numbers of juvenile steelhead opportunities to move into wetland habitats for food and refuge from predators. Moreover, the large amount of prey that moves out of reconnected sites over each tidal cycle (PNNL and NMFS 2020) increases prey for juveniles that stay in the mainstem. By promoting these juvenile behaviors, the estuary habitat improvement program contributes to the life-history diversity of populations in the UWR steelhead DPS.

(e.g., NMFS 2013c, 2016h, 2017f, 2017m, 2018b, 2019b, 2019e), so their effects are captured in the Environmental Baseline section of this opinion. The safety-net and conservation hatchery programs identified in the proposed action (BPA et al. 2020, USACE 2020) are intended to reduce extinction risk and promote recovery. The proposed action will have the same effects as those described generally in the Environmental Baseline section and in detail within the site-specific biological opinions referenced therein (see Section 2.14.2.7). Hatchery effects are also described in Appendix C of NMFS (2018a), which is incorporated here by reference. Potential effects include competition (for spawning sites and food) and predation effects, disease effects, demographic effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge). For efficiency, discussion of these effects is not repeated here. Hatchery production funded by the Corps in the upper Willamette River basin is associated with the Willamette Project dams and is not an effect of this proposed action. The Corps' Upper Willamette hatchery programs have undergone Section 7 consultation (NMFS 2019f).

2.14.3.1.5 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced level. Unless the NPMP's boat electrofishing efforts are reduced to zero when juvenile and adult UWR steelhead are likely to be present in shallow shoreline areas, an unknown portion of the DPS will continue to be stunned, harmed or possibly even killed. At present, in order to reduce take, field crews conducting these electrofishing efforts will release the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away. Due to the nature of boat electrofishing in general, and the conditions under which the program conducts boat electrofishing (nighttime, high turbidity), it is impossible to accurately estimate the number of fish from this DPS that are affected by these activities. At whichever level this method continues to be used in future years, quick, visual estimates of observed juvenile and adult salmonids will continue to be recorded. The (5-year) average number of observed salmonids being stunned and harmed annually by the project is ~90,000 for juveniles and ~1,600 for adults. Some of this take could result in injury or reduced fitness. These averages will be used as a benchmark to evaluate the success of NPMP RME activities and take reduction strategies as they are implemented in future years.[446]

The level of all other RME-related injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of fish, is likely to continue at a similar level. To estimate effects of planned RME activities on a listed salmon ESU or steelhead DPS, NMFS must consider effects on the entire ESU or DPS, including ESA-listed hatchery fish. However, estimating the effects to the natural-origin fish component alone can also be informative, as these fish are used to estimate most VSP metrics. For purposes of this opinion and given the available

[446] Ongoing and future discussions are expected to lead to substantial reductions in electrofishing efforts (tagging and sampling) by the NPMP. However, because the reductions that will ultimately result from these discussions are presently unknown and so, cannot be assessed with sufficient certainty, NMFS is assuming, for the purpose of this consultation, that the program will continue as currently implemented.

data, NMFS reports the number of listed hatchery- and natural-origin fish affected by CRS RME programs separately. The effect of the RME programs cannot be assessed at the population level because most of these activities occur in larger river segments where many populations (and multiple ESUs/DPSs) are migrating at the same time.

We estimate that, on average, the following number of UWR steelhead will be affected each year:

- Activities associated with the Smolt Monitoring Program and CSS:
  - Zero hatchery and natural-origin adults and juvenile will be handled and/or die.
- Activities associated with all other RME programs:
  - 80 hatchery and 30 natural-origin adults will be handled.
  - 10 hatchery and five natural-origin adults will die.
  - 1,000 hatchery and 1,000 natural-origin juveniles will be handled.
  - 10 hatchery and 10 natural-origin juveniles will die.

The combined take (i.e., handling, injury, and incidental mortality) associated with these elements of the RME program will, on average, affect 1.1 percent of the natural-origin adult (recent, 5-year average) run (arriving at mouth of the Columbia River) and 0.72 percent of the naturally produced juveniles (recent, 5-year average) (Thompson 2020). The effects of RME projects on overall adult and juvenile survival (estimated mortality) will be relatively small (total mortalities will amount to much less than 1 percent of estimated DPS abundance); the effects on fitness, while unquantifiable, are likely to be somewhat greater. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the small effects of the RME programs on abundance are acceptable and warranted.

2.14.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation will not affect the functioning of the juvenile or adult migration corridors for UWR steelhead. Implementation will affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary for all populations. Effects of the proposed action on the PBFs are described in Table 2.14-5.

Table 2.14-5. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the UWR steelhead DPS.

PBF	Effect of the Proposed Action
Freshwater spawning sites	Freshwater spawning sites used by UWR steelhead are in tributaries to the Willamette River and will not be affected by the proposed action.

PBF	Effect of the Proposed Action
Freshwater rearing sites	Freshwater rearing habitat used by UWR steelhead is in tributaries to the Willamette River and will not be affected by the proposed action. See also “estuarine areas.”
Freshwater migration corridors	Continued alteration of the seasonal flow regime (increased fall and winter and decreased spring and summer flows) due to operations at CRS reservoirs (reduced water quantity in the juvenile and adult migration corridors). The Action Agencies will continue to manage reservoir releases to seasonal flow objectives for fish survival based on the amount of runoff in a given year. Given the Action Agencies’ ability to meet the spring and summer flow objectives in the last 20 years, we expect this to be an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher flow years and a moderate negative effect in lower flow years. Proposed changes to reservoir operations at Grande Coulee, Libby, Hungry Horse, and Dworshak Dams will result in a small decrease in flows, but will not change the functioning of water quantity in the juvenile and adult migration corridors. Continued alteration of the seasonal temperature regime in the lower Columbia River due to thermal inertia associated with the CRS reservoirs. Generally cooler temperatures in the spring and warmer temperatures in the late summer and fall. In general, cooler spring temperatures will not adversely affect the functioning of the mainstem as a migration corridor for juvenile steelhead. Adults are winter-run and do not experience degraded water quality due to these temperature shifts. This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued reduced sediment discharge and turbidity in the lower river, especially during spring, which may increase the vulnerability of juvenile outmigrants to visual predators such as piscivorous birds and fishes in the lower Columbia River and the plume (ongoing reduction in “natural cover”). This effect is partly due to the existence of the dams, which is in the environmental baseline, and partly an effect of the proposed operations. Continued implementation of the NPMP to maintain fish predation (ongoing reduction in predation) at current levels.
Estuarine areas	Continued improvement in access to floodplain habitat for rearing and prey production with ongoing implementation of the estuary habitat program (improved access to natural cover, aquatic vegetation, and side channels; juvenile and adult forage). This will increase access to prey for yearling steelhead that remain in the mainstem. Continued implementation of the Caspian tern and double-crested cormorant management plans to limit nesting on Action Agency-managed properties below Bonneville Dam will continue recent levels of predation in the estuary, although cormorant predation rates may increase if more birds forage from upstream sites like the Astoria-Megler Bridge. Continued implementation of the NPMP to control levels of fish predation (ongoing reduction in levels of predation).

2.14.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 50 CFR 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Status (Section 2.14.1), Environmental Baseline (Section 2.14.2), and Effects of the Action (Section 2.14.3) sections.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem functions or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation), various stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including UWR steelhead.

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects result from activities that occurred in the recent past and were included in the environmental baseline. Some of the activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include activities associated with human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.14.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution; or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.14.5.1 Species

The UWR steelhead DPS includes all naturally spawned anadromous, winter-run O. mykiss originating below natural and manmade impassable barriers from the Willamette River and its tributaries upstream of Willamette Falls to, and including, the Calapooia River. There is only one major population group in this DPS, comprising four populations that produce low to moderate numbers of natural-origin steelhead each year. UWR steelhead are at low abundance and have declined in recent years. Tributary habitat has been substantially degraded, and access to higher quality habitat has been blocked by dams in the tributaries. Compared to previous data, the available monitoring information at Willamette Falls, Upper and Lower Bennett Dams on the North Santiam River, and Foster Dam on the South Santiam River suggests little to no improvement in the most recent abundance of adult winter steelhead. Recent poor ocean conditions associated with a marine heatwave and its lingering effects have likely contributed to lower than average ocean survival rates in recent years. Some of these negative effects had subsided by spring 2018, and expectations for marine survival were mixed for 2019 outmigrants.

The proposed 125 percent TDG spring spill operation should further increase spill levels at Bonneville Dam (limited to 150 kcfs), which will increase juvenile exposure to TDG for the few adult UWR Chinook salmon that occasionally pass upstream to Bonneville Dam. Other operations (e.g., Upper Columbia operations to better protect resident species, Dworshak Dam winter operations to reduce TDG in the lower Clearwater River, etc.) could, collectively, have a small, negative effect (slightly reduced flow), especially on juvenile migrants. However, these effects should not measurably alter juvenile survival rates.

Mainstem habitat in the Columbia River estuary has been substantially degraded, and access to historically available rearing habitat has been blocked as part of the existing condition. However, since 2007, over 10,000 acres of estuary rearing habitat has been conserved, reconnected, or restored as a result of the past implementation of the Action Agencies' estuary habitat improvement program, which has the potential to contribute to improving UWR steelhead abundance, productivity, and life-history diversity. The degradation and loss of mainstem and estuary rearing habitat is likely exacerbated by reduced flows in May and June (as a result of CRS water management activities) for juveniles that have not finished migrating to the ocean by the end of April. The proposed continuation of the estuary habitat program will effectively conserve some of the remaining productive floodplain habitat and reconnect additional areas—actions that are likely to provide measurable improvements to VSP metrics (abundance/productivity and life-history diversity) for all populations in this DPS. However, other factors (e.g., ocean conditions) also influence these viability parameters and any resulting trends.

Juvenile survival is also affected by large bird colonies (e.g., Caspian terns, double-crested cormorants, and gulls) and predatory fish. The Action Agencies propose to continue implementing the Caspian Tern Nesting Habitat Management Plan and the Double-crested Cormorant Management Plan. Using predation rates on LCR steelhead as a surrogate for UWR steelhead, management of the tern colony may be reducing mortality by a small amount compared to the pre-colony management period, but these gains in survival will continue to be tempered by ocean conditions, including compensatory effects. Cormorant predation rates may actually be increasing if birds continue to move from East Sand Island to the Astoria-Megler Bridge. Increased numbers of native and nonnative fishes that likely prey on juvenile UWR steelhead are also present in the Lower Columbia River. The NPMP is expected to continue providing similar benefits of predator removal (northern pikeminnow). Except for the Double-crested Cormorant Management Plan, these programs will maintain current (reduced) levels of predation, creating conditions that can contribute to improved levels of productivity and abundance, compared to conditions if these actions were not taken.

Pinniped predation on UWR steelhead in the Willamette River and lower Columbia River and estuary has increased substantially with recent increases in the abundance of sea lions, especially in the spring. Sea lion predation will continue to negatively affect the productivity and abundance of UWR steelhead.

The management of Willamette River steelhead hatchery programs has improved substantially compared to historical operations. However, while indicators of hatchery impacts (e.g., the proportion of hatchery origin spawners) on natural populations are expected to improve, hatchery production will continue to limit the diversity and productivity of natural populations of UWR steelhead.

Harvest rates on UWCR steelhead in fisheries have decreased compared to historical levels. Total freshwater harvest rates have averaged nearly 10 percent in recent years, and is expected to continue at these levels.

As described in Section 2.14.4, the cumulative effects of state and private actions that are reasonably certain to occur within the action area considered for UWR steelhead are variable. In urban areas, there will be continued population growth, but redevelopment and private restoration actions will begin to improve negative baseline conditions. Agricultural and forestry practices in rural areas will also continue at a scale similar to that in the past.

The quality of data used to evaluate climate-related threats is limited, and our understanding of how salmonids, and the ecosystems upon which they depend, might respond is even more limited. However, climate change would likely affect LCR steelhead in the following ways: 1) changes in ocean survival, 2) changes in growth and development rates, 3) changes in disease resistance, and 4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.). Recent analyses by Crozier et al. (2019) rated the vulnerability of UWR steelhead as high. We generally expect that abundance could decrease and extinction risk increase as a result of climate change.

Winter-run adults would avoid higher summer temperatures and could potentially respond temporally to changing environmental conditions by migrating and spawning earlier in time. Developing eggs and fry could be negatively affected by altered flows (e.g., low flows or flood events). Juvenile emergence and rearing could potentially become “out-of-sync” with nursery conditions in streams. Yearling migrants will be negatively affected because they would be exposed to higher summer temperatures. Though the quality of information is mixed, sensitivity in the marine stage is certainly high, and exposure to changing marine conditions, including high levels of ocean acidification, will occur. These climate change consequences are not caused by the proposed action. In simple terms, even if the adult abundance declines as a result of climate change, which will make recovery of this ESU more challenging, it will have declined no more so as a result of the proposed action.

The proposed action includes conservation measures to mitigate the potential adverse effects of the action, in many cases by addressing limiting factors for survival and recovery. These measures include estuary habitat improvement and predator management actions that should benefit VSP parameters, thus reducing the expected abundance declines caused by climate change. Collectively, the proposed action is likely to improve many factors identified in the recovery plan for this ESU (e.g., degraded estuary habitat, etc.) and will maintain current conditions for others (e.g., altered flows, altered water quality, reduced predation, etc.).

In conclusion, the proposed action includes some elements that will harm salmonids and some that will benefit salmonids. The proposed action influences freshwater survival and productivity. Since 2008, actions have been taken to reduce adverse impacts associated with the operations of the CRS and to address factors limiting survival and recovery (e.g., estuary habitat, predation, etc.). Evidence shows that these actions have resulted in improved freshwater survival and improved population productivity, and may improve spatial structure and diversity over time. Ecosystem functions should continue to increase in estuary habitats where improvement actions occur.

Climate change is a substantial threat to UWR steelhead, especially during the marine rearing phase of their life cycle. The proposed action should not exacerbate either the scope and/or severity of those impacts.

In short, it is NMFS' opinion that, when the effects of the action and cumulative effects are added to the environmental baseline, and in light of the status of the species, the effects of the action will not cause reductions in reproduction, numbers, or distribution that would reasonably be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of UWR steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of UWR steelhead.

2.14.5.2 Critical Habitat

Critical habitat for UWR steelhead encompasses seven subbasins in Oregon containing 28 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b, 2016e) and most of these watersheds have some, or a high, potential for improvement. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns.

The environmental baseline includes a broad range of past and present actions and activities that have affected the functioning of critical habitat for UWR steelhead. These include the effects of water storage, irrigation withdrawals, and hydropower generation in the Willamette River basin, changes in tributary and mainstem habitat (both positive and negative) for freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. Land use and development activities remain a concern; these include activities that affect the quality and accessibility of habitats and habitat-forming processes, such as riparian condition and floodplain function, as well as water quality (NMFS 2016e). In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for juvenile steelhead migrating in the mainstem. Toxic contamination and urban and industrial development in the lower Willamette and Columbia Rivers are also a concern.

Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of Federal, state, and local agencies; tribes; and other stakeholders. A number of restoration projects have been implemented in the lower Columbia River estuary, many of these funded through the CRS program. The Action Agencies' proposed estuary habitat program will continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to juvenile steelhead migrating to the ocean (improved forage in estuarine areas).

The Action Agencies will continue to operate storage reservoirs to meet mainstem flow objectives. Because their ability to meet these objectives depends on the amount of runoff expected, we expect an ongoing small negative effect on water quantity in the juvenile migration corridor in average to higher runoff years and a moderate negative effect in lower runoff years. We do not expect the proposed changes to reservoir operations at Grand Coulee, Libby, Hungry Horse, and Dworshak Dams to change the functioning of water quantity in the juvenile and adult migration corridors below the Willamette confluence. The thermal inertia created by the CRS reservoirs will not negatively affect temperatures (water quality) in the juvenile or adult migration corridors. Thus, the proposed action is not likely to further limit water quantity in the juvenile and adult migration corridors by a meaningful amount and will not affect obstructions.

The Action Agencies also will continue to implement the Sport Reward Fishery to remove predaceous northern pikeminnow throughout much of the lower Columbia River, and the predation management programs for terns and double-crested cormorants on East Sand Island in the lower estuary. We expect that these actions will maintain the levels of predation in the migration corridors that were achieved in recent years, although cormorant predation rates may further increase if more of these birds forage from upstream sites like the Astoria-Megler Bridge.

In the lower Columbia River estuary, more than 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications. This has reduced the production of wetland macrodetritus that supports salmonid food webs, both in shallow water and for larger juveniles migrating in the mainstem. A number of restoration projects have been implemented in the estuary, many of these funded through the CRS program. The Action Agencies propose to continue to reconnect an average of 300 acres of the historical floodplain per year, increasing the availability of wetland-derived prey to yearling steelhead migrating to the ocean (improved forage in estuarine areas) beyond the more than 6,000 acres of floodplain wetlands and 2,000 acres of floodplain lakes previously connected under this program.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Adding the effects of the action to the environmental baseline and the cumulative effects, and taking into account the status of critical habitat, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of UWR steelhead. Accordingly, it is NMFS' opinion that the proposed action is not likely to result in the destruction or adverse modification of UWR steelhead designated critical habitat.

2.14.6 Conclusion

After reviewing and analyzing the current status of UWR steelhead and its critical habitat, the environmental baseline, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of UWR steelhead or destroy or adversely modify its designated critical habitat.

2.15 Eulachon

This section applies the analytical framework described in Section 2.1 to the southern DPS of eulachon (also “southern DPS eulachon”) and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the DPS or destroy or adversely modify its critical habitat.

2.15.1 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of southern DPS eulachon, which would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species’ likelihood of both survival and recovery. The species status section also helps to inform the description of the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that conservation value.

2.15.1.1 Status of Species

2.15.1.1.1 Listing History

On March 18, 2010, NMFS listed the southern DPS eulachon as a threatened species (75 FR 13012), reaffirming this conclusion in its most recent 5-year status review (NMFS 2016j). Critical habitat was designated on October 20, 2011 (76 FR 65324). More information on the biology, ecology, and status of this species can be found in the recovery plan (NMFS 2017l). Table 2.15-1 summarizes listing and recovery plan information, status summary, and threats for eulachon.

Table 2.15-1. Status review summary and threats to the viability of southern DPS eulachon.

Status Summary	Threats (BRT Ratings)
The southern DPS of eulachon comprises fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. Four "subpopulations" are considered in NMFS' recovery plan as a minimum set of "populations" that are needed to meet biologically based and threats-based delisting criteria: the Klamath River, the Columbia River, the Fraser River, and the British Columbia coastal rivers. Starting in 1994, there was an abrupt decline in the abundance of eulachon returning to all subpopulations, including the Columbia River. Despite a brief period of improved returns in 2001 to 2003, the returns and associated commercial landings were at low levels from the mid-1990s through the 2000s. Eulachon abundance in monitored rivers improved in the 2013 to 2015 return years, before declining again in 2016 through 2019, most likely due to recent poor ocean conditions. However, for 2020 the run in the Columbia River has improved moderately likely due to favorable ocean conditions.	High: climate change impacts on ocean conditions High–Moderate: ocean fisheries bycatch Moderate: climate change impacts on freshwater habitat Moderate: predation Moderate–Low: water quality Moderate–Very Low: dams and water diversions Moderate–Very Low: shoreline construction Moderate–Very Low: dredging

Eulachon in the listed southern DPS are primarily a marine pelagic species that spawn in the lower reaches of coastal rivers and whose primary prey is plankton (Gustafson et al. 2010). They are typically found in near-benthic habitats in open marine waters of the continental shelf with depths between 66 and 400 feet (Hay and McCarter 2000).

The southern DPS eulachon comprises fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. Four subpopulations[447]—the Klamath River, the Columbia River, the Fraser River, and the British Columbia coastal rivers—are considered in NMFS' recovery plan as a minimum set of "populations" that are needed to meet biologically based (abundance, productivity, spatial distribution, and genetic and life-history diversity) and threats-based delisting criteria (NMFS 2017l).

Presently, most eulachon production south of the U.S.–Canada border originates in the Columbia River basin, including the Columbia, Cowlitz, Grays, Kalama, Lewis, and Sandy Rivers (Gustafson et al. 2010). Historically, eulachon were occasionally reported to spawn in tributaries as far upstream as the Hood River (Oregon) and the Klickitat River (Washington) (NMFS 2017l). Since Bonneville Dam was completed in 1937, there have been occasional observations

[447] There are many "populations" of eulachon within the range of the species. For their threats analysis, the BRT did not include all known or possible eulachon spawning areas. As such, the BRT partitioned the southern DPS eulachon into geographic areas, i.e., subareas/subpopulations, for their threats assessment. Thus, the subpopulation structure used by the BRT leaves out some "populations" within the DPS (e.g., Elwha River, Naselle River, Umpqua River, and Smith River) that we now know may have (or have had) some important contribution to the overall productivity, spatial distribution, and genetic and life-history diversity of the species (NMFS 2017l). At present, it is not known whether eulachon are one large metapopulation or comprise multiple demographically independent populations.

of eulachon at, or even above (passing through the ship locks), the dam in years when eulachon were highly abundant (NMFS 2017l).

Starting in 1994, southern DPS eulachon experienced an abrupt decline in abundance throughout its range. Eulachon abundance in monitored rivers improved in the 2013 to 2015 return years, but recent poor conditions in the northeastern Pacific Ocean appear to have driven sharp declines in the river systems in 2016 and 2017.

No reliable fishery-independent, historical abundance estimates exist for eulachon. From 2000 through 2019, mean spawning stock biomass estimates in the Columbia River ranged from a low of about 783,000 fish in 2005 to a high of nearly 186 million fish in 2014, and in 2019 an estimate of 46.7 million fish. Spawning stock biomass estimates in the Fraser River (1995 to 2019) ranged from a low of about 110,000 to 150,000 fish in 2010 to a high of about 42 million to 56 million fish in 1996. Fishery-independent estimates are not available for the Klamath River or British Columbia coastal rivers (NMFS 2017l).

The BRT rated climate change impacts on ocean conditions as the highest threat to the persistence of eulachon subpopulations, followed by bycatch in coastal shrimp fisheries. The latter was likely reduced in recent years with the addition of lights and excluder devices to shrimp gear, developed specifically to reduce eulachon bycatch. Dams and water diversions, climate change impacts on freshwater habitat, predation, water quality, shoreline construction, and dredging were all rated as having moderate impacts for at least one subpopulation (NMFS 2017l).

2.15.1.2 Status of Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential PBFs of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Table 2.15-2 summarizes designated critical habitat based on the detailed information on the status of critical habitat throughout the designation area provided in the recovery plan for the species (NMFS 2017l).

PBFs essential to the conservation of the southern DPS fall into two major categories reflecting key life-history phases of eulachon:

- Freshwater spawning and incubation sites with water flow, quality, and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles. These features are essential to conservation because without them, the species cannot successfully spawn and produce offspring.
- Freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction; feature water flow, quality, and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval

feeding after the yolk sac is depleted. These features are essential to conservation because they allow adult fish to swim upstream to reach spawning areas, and they allow larval fish to proceed downstream and reach the ocean.

Table 2.15-2. Critical habitat, designation date, Federal Register citation, and status summary for eulachon critical habitat.

Designation Date and Federal Register Citation	Critical Habitat Status Summary
10/20/2011 **76 FR 65324**	Critical habitat encompasses 16 rivers (up to the ordinary high water line/bankfull elevation in streams and tidally influenced areas in estuaries) in California, Oregon, and Washington: Mad River, CA; Redwood Creek, CA; Klamath River, CA; Umpqua River, OR; Tenmile Creek, OR; Sandy River, OR; Columbia River, OR and WA (up to Bonneville Dam); Grays River, WA; Skamokawa Creek, WA; Elochoman River, WA; Cowlitz River, WA; Toutle River, WA; Kalama River, WA; Lewis River, WA (up to Merwin Dam); Quinault River, WA; and Elwha River, WA; excepting Indian lands of the following Federally recognized tribes in the same states (Resighini Rancheria, CA; Yurok Tribe, CA; Quinault Tribe, WA; and Lower Elwha Tribe, WA). Compared to historical conditions, most watersheds with PBFs for eulachon are currently degraded, at least to some extent, by human activities, climate change impacts to the ocean and freshwater habitat, urbanization and rural residential development, transportation corridors, industry, predation (by nonindigenous species), water quality, dams and water diversions, shoreline construction (e.g., pile dikes, jetties, bank armoring, and levies), and dredging (NMFS 2017l).

2.15.1.3 Climate Change Implications for Eulachon and Critical Habitat

One factor affecting eulachon and its critical habitat is climate change. In 2010, the BRT concluded that climate change is one of the major threats to this DPS (NMFS 2016j). The BRT ranked climate change impacts on ocean conditions as the most serious threat to persistence of eulachon, and scored climate change impacts on freshwater habitat and eulachon bycatch as posing moderate to high extinction risk in all subareas of the DPS. The 2010 BRT also noted concern that climate change may have contributed to a mismatch between timing of ocean entry of eulachon larvae and availability of crucial prey species. However, the ability of the Columbia River eulachon stock to respond rapidly to the good ocean conditions of the late 1999 to early 2002 period illustrated the species' resiliency, and the 2010 BRT viewed this resiliency as providing the species with a potential buffer against future environmental perturbations.

The climate we experience is a combination of natural variability and long-term change. Climate change is not detectable day to day or year to year, but rather through long-term trends in daily and annual temperatures (Link et al. 2015). These long-term changes in the Earth's climate system pose challenges for the management of anadromous fish. Information on the impacts of climate variability and change on eulachon is very important to developing effective management approaches across multiple time scales.

Climate change impacts on ocean conditions (i.e., as measured by large-scale spatial and temporal shifts in oceanic-atmospheric patterns in the northeastern Pacific Ocean associated with both natural climate variability and anthropogenic-forced climate change) are probably the principal threat to eulachon, as ocean condition is the one phenomenon that correlates with the recent species-wide declines in abundance. While the specific characteristics that provide favorable marine conditions for eulachon in the northeastern Pacific Ocean are unknown, available information suggests that there is a link between the PDO (Gustafson et al. 2010) and other marine indices, such as the ENSO, the Oceanic Niño Index, and the Northern Oscillation Index, and eulachon survival, abundance, and recruitment potential. One hypothesis is that cool-phase PDO cycles are associated with greater primary and secondary productivity in the northern California Current (Figure 2.15-1) that provides abundant food resources for multiple age classes, especially larval eulachon entering the marine environment.

Likely changes in temperature, precipitation, wind patterns, and sea level have profound implications for survival of eulachon in both their freshwater and marine habitats. Recent descriptions of expected changes in the Pacific Northwest climate that are relevant to eulachon include Elsner et al. (2009), Mantua et al. (2009), Mote and Salathe (2009), Salathe et al. (2009), and Gustafson et al. (2010). Reviews of the effects of climate change in the Columbia River basin include ISAB (2007), Hixon et al. (2010), Dalton et al. (2013), and NMFS (2014a).

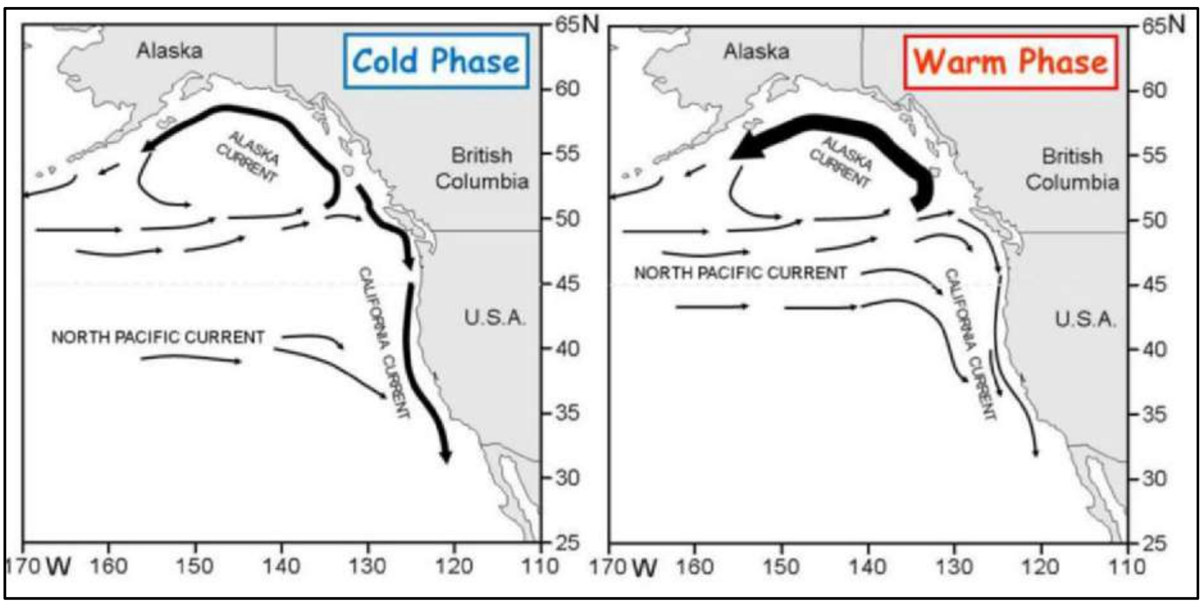

Figure 2.15-1. A working hypothesis on how changes in the Pacific Decadal Oscillation affect productivity in the northern California Current. Source: Peterson et al. 2013.

The following is a summary of expected climate change-related effects on eulachon and their habitats derived from the above sources.

2.15.1.3.1 Freshwater Environments

Climate records show that the Pacific Northwest has warmed about 1.3ºF from 1895 to 2011 (Melillo et al. 2014), or about 50 percent more than the global average warming over the same period (Dalton et al. 2013). As the climate changes, air temperatures in the Pacific Northwest are expected to increase in average of 3.3°F to 9.7°F by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios); the increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018).While total precipitation changes are predicted to be minor (+1 to 2 percent), increasing air temperature will alter the snow pack, streamflow timing and volume, and water temperature in the Columbia River basin. Climate scientists predict the following physical changes to rivers and streams in the Columbia River basin:

- Warmer temperatures will result in more precipitation falling as rain rather than snow, and snowpack will diminish, water temperatures will increase, and stream flow volume and timing will be altered.

2.15.1.3.2 Estuarine and Plume Environments

Climate change will also affect eulachon in the Columbia River estuary and plume.[448] In the estuary, eulachon would be primarily affected by increased water temperatures, flow-related changes, altered phytoplankton and zooplankton prey, and increased predation. Eulachon may be affected by habitat changes in the plume environment due to flow- or sediment-related changes; however, use of plume habitat by eulachon remains poorly understood. Effects of climate change on eulachon in the estuary and plume may include the following:

- Higher winter freshwater flows and higher sea levels may increase sediment deposition in the plume, possibly reducing the quality of rearing habitat.
- Lower freshwater flows in late spring and summer may lead to upstream extension of the salt wedge, possibly influencing the distribution of eulachon prey and predators.
- Increased temperature of freshwater inflows and seasonal expansion of freshwater habitats may extend the range of nonnative, warm-water species that are normally found only in freshwater.

In all of these cases, the specific effects on eulachon abundance, productivity, spatial distribution, and diversity are poorly understood.

2.15.1.3.3 Marine Environments

Effects of climate change in marine environments include increases in ocean temperature, stratification of the water column, and ocean acidification, and changes in intensity and timing of coastal upwelling. Hypotheses differ regarding whether coastal upwelling will decrease or

[448] The Columbia River plume is defined as those waters contiguous to the mouth of the Columbia River having salinity less than 32.10 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005).

intensify, but even if it intensifies, the increased stratification of the water column may reduce the ability of upwelling to bring nutrient-rich water to the surface. Climate models also indicate that future conditions in the North Pacific region will trend toward conditions that are typical of the warm phases of the PDO, but the models in general do not reliably reproduce the oscillation patterns. Hypoxic conditions observed along the continental shelf in recent years appear to be related to shifts in upwelling and wind patterns that may be related to climate change.

Climate-related changes in the marine environment are expected to alter primary and secondary productivity, the structure of marine communities, and, in turn, the growth, productivity, and survival of eulachon, although the degree of impact on eulachon is currently poorly understood. Earlier peak spring freshwater flows can decrease the incubation period and lead to reduced larval survival, which, when coupled with altered upwelling may result in reduced marine survival rates.

Ocean warming may also change migration patterns, thus increasing distances to feeding areas and reducing eulachon survival. Rising atmospheric carbon dioxide concentrations drive changes in seawater chemistry, increasing the acidification of seawater and thus reducing the availability of carbonate for shell-forming invertebrates. This process of acidification is underway. It has been well documented along the Pacific coast of the United States and is predicted to accelerate with increasing greenhouse gas emissions. Ocean acidification has the potential to reduce survival of many marine organisms, including eulachon. However, because there is currently a paucity of research directly related to the effects of ocean acidification on fish and their prey, potential effects are uncertain. Laboratory studies on prey taxa have generally indicated negative effects of increased acidification, but how this translates to the population dynamics of eulachon prey and the survival of eulachon is uncertain.

Despite this uncertainty regarding the mechanism of potential impacts, we consider the extinction risk to eulachon from the effects of climate change in the marine environment to be high.

2.15.2 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or its designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

For southern DPS eulachon, we focus our description of the environmental baseline on the portion of the action area where eulachon are exposed to the effects of the proposed action.

The Columbia River and its tributaries support the largest eulachon run in the world (Hay et al. 2002). Eulachon use the mainstem Columbia River within the action area to migrate to spawning grounds as adults and to emigrate from freshwater into marine waters as larvae. Large spawning aggregations of eulachon have been observed in the mainstem Columbia River and in the Cowlitz, Lewis, and Sandy Rivers (Craig and Hacker 1940); Grays River (Smith and Saalfeld 1955); Kalama River (DeLacy and Batts 1963); Elochoman River; and in Skamokawa Creek (WDFW and ODFW 2001). Smith and Saalfeld (1955) stated that eulachon were reported to spawn up to the Hood River on the Oregon side of the Columbia River before the construction of Bonneville Dam (in 1938), but were not known to ascend beyond Cascade Rapids until 1896 when the locks and canal were built for steamboat passage. The upstream extent of eulachon distribution is the Bonneville pool, and they travel downstream to the plume.

Southern DPS eulachon use the mainstem Columbia River within the action area for:

- Migrating to spawning grounds as adults—Migrations are associated with higher tides and water temperatures ranging from 40 to 50°F and can occur as early as November or as late as June, with peak spawning typically occurring sometime from January through March.
- Spawning, incubation, and rearing—the great majority of adults are semelparous and spawn only once; eggs are fertilized and drift downstream, adhering to sand and small gravels, and hatch in 3 to 8 weeks depending on water temperatures. Incubation is temperature-dependent, and so incubation times can differ among rivers and years. Larvae are transported downstream, where they forage on small prey items.
- Migrating downstream to the ocean as juveniles—after rearing for an unknown amount of time, eulachon move to the ocean where they generally remain for 2 to 5 years before returning to spawn (NMFS 2014a, 2017l).

2.15.2.1 Mainstem Habitat

Aquatic habitats have been significantly modified in the lower Columbia River by a variety of anthropogenic activities, including dams and water diversions, dredging, urbanization, agriculture, silviculture, and the construction and operation of port and shipping terminals. Since the development of the Canadian and FCRPS storage projects in the upper Columbia River basin (1940s through 1970s), water is stored during spring and released for power production and flood control during winter, shifting the annual hydrograph. Water withdrawals and flow regulation in the Columbia River basin have reduced the Columbia River's average flow, altered its seasonality, and altered sedimentation processes and seasonal turbidity events, e.g., estuary turbidity maximum (Simenstad et al. 1982, 1990; Sherwood et al. 1990, NRC 1996, Weitkamp 1994, as cited in NMFS 2008a). Water withdrawals and flow regulation have significantly affected the timing, magnitude, and duration of the spring freshet through the Columbia River estuary such that they are about one-half of the pre-development levels (NMFS 2008a), all of which are important for eulachon adult, larval, and egg life stages.

In the Columbia River estuary, both the quantity and timing of instream flows have changed from historical conditions (Fresh et al. 2005). Jay and Naik (2002) reported a 16 percent reduction of annual mean flow over the past 100 years and a 44 percent reduction in spring freshet flows. Jay and Naik (2002) also reported a shift in flow patterns in the Columbia to 14 to 30 days earlier in the year, meaning that spring freshets are occurring earlier in the season. In addition, the interception and use of spring freshets (for irrigation, reservoir storage, etc.) have caused increased flows during other seasons (Fresh et al. 2005). It is unknown what effect these changes in hydrology may have on eulachon habitat.

Total sediment discharge into the estuary and Columbia River plume is now only one-third of 19th-century levels (Simenstad et al. 1982, 1990; Sherwood et al. 1990, Weitkamp 1994, NRC 1996, NMFS 2008a). Bottom et al. (2005) estimated that the combined effect of all activities throughout the Columbia River basin on sediment transport has been more than a 50 percent reduction in suspended sediment and fine sediment transport as measured at Vancouver, Washington. Thus, less fine sediment and sand are available to replenish habitat along the margins of the river. In addition, reduced sediment discharge results in reduced turbidity in the lower river, especially during spring, may make adult eulachon more vulnerable to visual predators like piscivorous birds and fishes.

Water management and hydroelectric developments have altered the mainstem flow regime, generally increasing winter flows (November through March) and reducing peak spring flows (May and June). These activities also have affected water temperatures as well (generally increasing minimum temperatures during the winter spawning season and decreasing spring temperatures) (NMFS 2008a). While the effects of water management operations throughout the basin are substantial, it is unknown whether these alterations in flow or temperature have positive, neutral, or negative effects on eulachon spawning, incubation, and rearing (NMFS 2014a). However, it seems most likely that, to the extent there are adverse effects, they would affect larval eulachon migrating through the estuary and into the ocean in May or June, when flows (and turbidity) are substantially diminished compared to historical conditions.

Implementation of the RPAs in the 2008 FCRPS biological opinion, as amended in 2010 and supplemented in 2014 and 2019 (minimized flood control drafts, “dry-year” operations, etc.), has incrementally made the seasonal flow regime during the winter and spring more like the conditions that occurred before the construction of large storage facilities in the 1960s and 1970s. Assuming that eulachon are adapted to historical flow conditions, these changes would be expected to have a small but positive effect on migration conditions for eulachon larvae and adults in the mainstem Columbia River, estuary, and plume compared to prior decades.

Eulachon only encounter one mainstem dam in the CRS: Bonneville Dam. When adult eulachon reach the tailrace of Bonneville Dam, small numbers are able to pass upstream via either the adult fishways designed for salmon and steelhead or through the locks. Some of those that do pass likely “fall back” downstream through turbines or juvenile bypass systems, where they can be injured or killed. If spawning occurs upstream of Bonneville Dam, eulachon larvae would likely be affected by habitat inundation, reduced water velocities, altered fish community structure, and physical features of dams such as turbines or screens that could injure or kill drifting larvae.

In 1953, eulachon were observed spawning in Tanner Creek on the Oregon side of the Columbia River near the base of Bonneville Dam. As described in the 2014 FCRPS supplemental biological opinion and by the Pacific States Marine Fisheries Commission (2014), the Corps has reported the following observations of adult eulachon in the smolt monitoring facility on the upstream side of Bonneville Dam:

- 1988 – 8,200 adults
- 2003 – two adults
- 2005 – five adults
- 2014 – 455 adults

No eulachon were reported at Bonneville Dam during 2015 to 2019. Applying the hourly sampling rates to the 8,200 adults observed in 1988 suggests a maximum fallback rate of about 95,500 adults through the bypass system in any given year. However, because the observation of fallback in 1988 was more than an order of magnitude higher than any since then, we consider this maximum fallback rate to be a highly conservative assumption.

Eulachon in Bonneville Reservoir and for at least 35 miles downstream of Bonneville Dam (Camas-Washougal gage) are also exposed to elevated levels of TDG, caused primarily by juvenile fish passage spill (beginning in April) or spill resulting from lack-of-load situations (year-round, but most common during spring). Exposure to elevated TDG is not a concern for adults because spawning is mostly completed by March, before the high spill period. The fertilized eggs adhere to the coarse substrates at the bottom of the river, and larval densities have been observed at higher abundance in mid- and bottom water samples in the Columbia River (Howell et al. 2001). Therefore, eulachon are likely to avoid GBT due to their tendency to remain at greater depths. Once spawning has occurred, the larvae are flushed rapidly to the ocean, further minimizing exposure time to increased TDG. Finally, even though eulachon have been observed migrating up the Columbia River as far as Bonneville Dam, eggs have been collected and spawning presumed from RM 35 up to RM 73 in the mainstem Columbia River (NMFS 2010a) indicating that most spawning takes place in the lower reaches of the tidally-influenced estuary and its tributaries. Thus, we expect the percentage of the run that will be exposed to elevated TDG levels to be very small.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005, Fresh et al. 2005, NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and Oregon's Willamette River as a navigation channel. The Federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The lower Columbia River supports five ports on the Washington State side: Kalama, Longview, Skamania County, Woodland, and Vancouver. In addition to loss of riparian habitat and disruption of benthic habitat due to dredging, high levels of several sediment chemicals that are harmful to fish at certain concentrations, such as arsenic and PAHs, have been identified in lower Columbia River watersheds in the vicinity of the ports and associated industrial facilities. Small releases of materials such as lubricants occur during dam operation and maintenance and contribute to background exposure to contaminants in the Columbia River. These factors could negatively affect embryonic development, growth rates, and egg, larval, and adult survival rates and are rated a moderate risk in the most recent 5-year review (NMFS 2016j).

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Outside of this urban area, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival). Given that eulachon are present only in the winter and spring months, some of these factors (e.g., warmer temperatures and lower dissolved oxygen) are not likely to meaningfully affect them. The effect of contaminants (e.g., increased bacteria, pesticides, and urban runoff) on eulachon is unknown, but likely to have at least some negative effect to those individuals (adults, eggs, or larvae) exposed to these substances.

Changes in the seasonal hydrograph as a result of water use and reservoir storage have also altered habitat-forming processes, including the size of the plume compared to historical conditions. However, no hypotheses have been advanced that would link these changes to the viability of Southern DPS eulachon.

2.15.2.2 Passage Survival

Adult eulachon occasionally reach Bonneville Dam, which blocks or impedes and delays their migration. Some still pass upstream, and it is likely that those that “fall back” are negatively affected by dam structures. If they spawn successfully, it is likely that the resulting eulachon larvae are negatively affected by dam structures (e.g., turbines, screens, etc.). Although recent structures and operations to improve passage conditions for juvenile salmonids (e.g., Powerhouse 2 corner collector and the spring spill program), these structural and operational improvements are unlikely to reduce these effects for larval eulachon that are still in the system in April when these systems are operating.

2.15.2.3 Estuary Habitat

Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, shoreline development, flow regulation, and other modifications (Kukulka and Jay 2003, Bottom et al. 2005, Marcoe and Pilson 2017, Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus and flux to the mainstem during peak spring flows. From 2007 through 2019, the Action Agencies implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historical tidal floodplain habitat. In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation. These recent efforts to reconnect portions of the historical floodplain (Johnson et al. 2018) are expected to improve material fluxes between terrestrial and wetland areas and the mainstem and thus better support phytoplankton production in the lower river. Phytoplankton is the primary food resource for eulachon larvae in the estuary and plume. Larval eulachon are small and have little to no ability to direct their movement in a large river. They appear to drift passively and rapidly, feeding as they drift downstream (McCarter and Hay 2003). Thus, while shorelines have been substantially impacted, it is not clear that these shallow-water areas are important for larval eulachon.

2.15.2.4 Hatcheries

Eulachon larvae and salmon juveniles/smolts, especially hatchery fish, have different habitat requirements. Larval eulachon are carried downstream and dispersed by river and tidal currents, and are generally distributed throughout the water column. The large salmon and steelhead smolts released by hatcheries migrate rapidly through the Columbia River estuary to the ocean, with most migrating in or near the navigation channel. Smaller juveniles (e.g., subyearlings released from summer and fall Chinook hatchery programs in the upper Columbia River basin) are frequently seen in floodplain wetlands and along the shoreline, but these are not areas frequented by larval eulachon. Therefore, competition for space is likely to minor, if it occurs at all. There is some potential for juvenile hatchery-origin salmon to prey on eulachon larvae. However, juvenile salmon and steelhead captured in the Columbia River estuary have eaten primarily aquatic and terrestrial insects (e.g., dipterans, hemipterans), amphipods, mysids, and freshwater crustaceans (PNNL and NMFS 2018). Unidentified larval fish made up a very small portion of the juvenile salmonid diet (PNNL and NMFS 2020). Thus, the effects of predation by juvenile salmonids released from Columbia River basin hatcheries is likely to be low.

2.15.2.5 Recent Ocean and Lower River Harvest

Between 1988 and 2010, the states of Washington and Oregon maintained commercial and recreational fisheries for eulachon. In the commercial fishery, eulachon were caught using small-mesh gillnets (i.e., <2 inches) and small mesh dipnets (although small trawl gear is legal, it is rarely used). However, in 2010, following the listing of eulachon under the ESA, Washington and Oregon permanently closed the commercial and recreational eulachon fisheries.

In 2014, the states of Washington and Oregon adopted a limited-opportunity recreational and commercial fishery on eulachon in the Columbia River, as well as the Cowlitz and Sandy Rivers; this fishery required using the small mesh fishing gear (TAC 2017). Salmon fisheries in the Columbia River use nets with large mesh sizes (i.e., >4.25 inches at all times), and hook-and-line gear designed to catch these species, which are much larger than eulachon. Encounters of eulachon in salmon fisheries are extremely unlikely given their general differences in temporal distribution and gear characteristics (TAC 2017). NMFS is not aware of any record of eulachon caught in either commercial or recreational salmon or steelhead fisheries operated in the Columbia River. NMFS' recovery plan for the southern DPS eulachon lists the level of threat for fisheries in the Columbia River as "low" (NMFS 2017l). Given all of the above, it is extremely unlikely that eulachon will be caught or otherwise affected by the fisheries.

2.15.2.6 Predation

2.15.2.6.1 Avian Predation

Researchers studying Caspian terns at East Sand Island saw terns carrying fresh adult eulachon back to the colony in late April, 2014 (Roby 2018). Fork lengths of two fish that terns dropped measured 198 and 218 mm, respectively. As measured by catches in the recreational fishery, the 2014 eulachon run was relatively large in the Columbia River and somewhat late so that this species was available during the nesting season. Eulachon were not identified as tern prey in other years, indicating that avian predation on adults is not a risk factor at the DPS level (Roby 2018).

2.15.2.6.2 Fish Predation

The NPMP includes the Sport Reward Fishery and Dam Angling Program. Continuation of the program will result in the ongoing removal of predaceous northern pikeminnow within Bonneville Reservoir and the lower Columbia River estuary. While the potential benefit of this program for eulachon has never been assessed, northern pikeminnow are generalist predators that are likely to consume eulachon adults, eggs, and larvae when they are available. No incidental catch of eulachon was reported for the Sport Reward Fishery or Dam Angling Program during 2014 to 2018 (Williams 2014; Williams et al. 2015, 2016, 2017, 2018).

2.15.2.6.3 Pinniped Predation

Sea lions and harbor seals are known predators of adult eulachon. The abundance of harbor seals in the Columbia River has been relatively consistent since the late 1980s (NMFS 2014a). Since the mid-2000s, California sea lions (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*) are much more abundant in the lower Columbia River than in prior decades (NMFS 2014a, 2016b). As a result, increased pinniped predation on adult eulachon is likely and is expected to continue for the foreseeable future.

2.15.2.7 Research, Monitoring, and Evaluation Activities

The primary effects of the past and ongoing CRS-related RME programs on eulachon are those associated with the capturing and handling of adult fish. The RME program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. Some RME actions also involve sacrificial sampling of fish. We estimated the number of adult eulachon that have been handled each year during the implementation of RME under the 2008 RPA and 2019 RPM as the average annual take reported for 2016 to 2019, as follows:

- Zero eulachon were handled by the Smolt Monitoring Program and none were killed.
- Zero eulachon were handled or killed during other RME activities.

Eulachon have not been encountered during April to July electrofishing operations conducted under the NPMP. Spawning is mostly completed by the end of March and out-going juveniles leave freshwater by mid-April (NMFS 2017l). Further, electrofishing operations are limited to shoreline habitat less than 3-m deep, which is a small portion of the water column where eulachon are likely to be present.

2.15.2.8 Critical Habitat

NMFS (2011) designated critical habitat for the southern DPS eulachon in the lower Columbia River up to Bonneville Dam and in tidally influenced areas in the Sandy, Grays, Elochoman, Cowlitz, Toutle, Kalama, and Lewis River subbasins and in Skamokawa Creek. The environmental baseline for the PBFs for eulachon critical habitat is reflected in the effects on the physical and biological features needed for conservation discussed above (e.g., mainstem flows, water quality, and predation) and summarized in Table 2.15-3.

Table 2.15-3. Physical and biological features (PBFs) of designated critical habitat for the southern DPS eulachon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning and incubation sites	Water flow, quality, and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles.	Less fine sediment and sand available to replenish habitat along the margins of the river, at least as far downstream as the Willamette River confluence (hydrosystem development and operations). Altered mainstem flow regime, generally increasing winter flows (November through March), when eulachon are present, and reducing peak spring flows (May and June) (water management). Altered mainstem water temperatures (generally increasing minimum winter temperatures, during spawning season, and decreasing spring temperatures) (hydrosystem development and operations; climate change). Alteration of mainstem spawning and incubation habitat by dredging (navigation).

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
		Increased levels of toxic contaminants (land use, industrial development). Increased levels of nutrients and fecal bacteria, lower dissolved oxygen in shoreline areas near leaking septic systems (rural residential and urban development). Risk of injury or mortality for adults that pass Bonneville Dam (most likely through the navigation lock) and fallback downstream [Jan-Mar] (hydrosystem development and operations). Increased exposure of eggs and larvae to total dissolved gas in Bonneville Reservoir and for greater than 35 miles downstream for late migrants that are still in the mainstem when spring spill operations begin on April 10 (hydrosystem development and operations).
Freshwater and estuarine migration corridors	Free of obstruction and with water flow, quality, and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted.	Reduced turbidity with potential for increased vulnerability to predators (hydrosystem development and operations). Risk of injury or mortality for adults that pass Bonneville Dam (most likely through the navigation lock) and fallback downstream [Jan-Mar] (hydrosystem development and operations). Loss of a large proportion of the estuarine floodplain (agricultural, rural residential, urban, and industrial development). Recent floodplain reconnection projects are expected to support the production of eulachon prey (phytoplankton) in the lower river by improving the flux of organic material and nutrients (habitat restoration).

2.15.2.9 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The most recent 5-year review evaluated new information regarding the status and trends of eulachon, including recent biological opinions issued for eulachon and key emergent or ongoing habitat concerns (NMFS 2016j). From January 2015 through May 22, 2020, we completed 139 formal consultations that addressed effects to eulachon.[449] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed

[449] PCTS data query, July 31, 2018; ECO data query, May 22, 2020. Data for 2018 were not available due to a change in database reporting systems, so consultations completed in 2018 are not included.

salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve riparian conditions and increase channel complexity and instream flows. For example, under its Habitat Improvement Programmatic Consultation (NMFS 2013a), BPA implemented 118 projects in the Columbia River basin in 2018 (the last year for which data are available) that involved river, stream, floodplain, and wetland restoration. However, it is rare for these projects to have specifically targeted habitats important for eulachon spawning and incubation.

Other types of Federal projects, including grazing allotments, dock and pier construction, and bank stabilization, could be neutral or have short- or even long-term adverse effects on eulachon. However, all of these actions have undergone section 7 consultation and the proposed actions or any RPAs were found to meet the ESA standards for avoiding jeopardy.

Similarly, future Federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation, but may have some adverse effects. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. Again, these actions rarely target habitats important to eulachon. All of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.15.3 Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 202.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect eulachon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for salmonid conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2020.

The effects of the proposed action are generally consistent with the effects caused by recent CRS operations as described in the environmental baseline section, with the addition of the proposed increase in spring spill. The other operational changes are not anticipated to alter the effects to southern DPS eulachon because very few or no fish in the DPS will be exposed to the effects of those changes.

2.15.3.1 Effects to Species

Eulachon adults, eggs, and larvae have the potential to be exposed to effects of the proposed action, including flow management and floodplain reconnection in the mainstem Columbia River from Bonneville Reservoir and Dam downstream to the Columbia River plume. In some years (potentially associated with larger spawning runs), some fraction of eulachon spawners will be affected by Bonneville Dam and its impoundment; passage upstream of the dam can be impeded or delayed by the presence of the dam.

2.15.3.1.1 Hydrosystem Operation

The effects of the continued operation of the CRS (system-wide water management operations) are essentially a continuation of the effects of recent system operations described in the Environmental Baseline section above, with the addition of the proposed increase in spring spill at the eight run-of-river dams. The continued effects include reduced sediment transport, altered hydrograph, altered water temperature regime, and impaired passage to areas above Bonneville Dam. The Action Agencies have not evaluated the specific effects of Bonneville Dam fish passage improvements, designed for juvenile salmonids, on eulachon, but no eulachon have been observed in the smolt monitoring facility since 2014 (Section 2.15.2.1). The proposed operation of the CRS will continue to have the potential to affect the eulachon spawning production, egg incubation, and larval and juvenile growth, development, and survival in the estuary–plume environment by modifying the seasonal hydrograph (Section 2.15.2.1). However, specific mechanisms are unknown.

During periods of increased spill at Bonneville Dam between April 10 and June 15 resulting from the proposed flexible spring spill operation, increased numbers of adult eulachon could fallback if they have successfully passed upstream via the adult salmon ladders or navigation locks. For example, higher spill is correlated with fallback behavior at Bonneville Dam for adult Chinook salmon and steelhead. Given their much smaller size, it is likely that adult eulachon would be less able to direct their movement with the increased percent of flow going over the spillway. However, the lack of survival estimates for eulachon (adult) through any passage route at Bonneville Dam make it unclear whether the changes in operations would positively, neutrally, or negatively affect the survival of eulachon, but if increased spills lead to increases fallback of adults, it would also lead to a decrease in spawning success.

2.15.3.1.2 Predation Management

The Corps and BPA will continue to support spring sea lion hazing, dissuasion, and removal efforts in the area downstream of Bonneville Dam beginning March 31 of each year. However, given the inconsistent presence of adult eulachon at Bonneville Dam, these efforts probably have little effect on the survival of eulachon or abundance at the population level. The deployment of sea lion excluder gates in the entrances to the adult fishways should prevent eulachon from entering the fishways.

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). However, observations of terns or cormorants eating eulachon are rare, and it is unlikely that these colony management actions are improving the survival of adults at the population scale.

2.15.3.1.3 Habitat Actions

The Action Agencies have not proposed to improve spawning and incubation habitat used by eulachon on tributaries to the lower Columbia River.

The Action Agencies will continue to implement the CEERP to increase the capacity and quality of estuarine ecosystems by continuing to reconnect roughly 300 acres of the historical floodplain per year to the tidal regime, a goal that they have a record of achieving in 2008 to 2019 (BPA et al. 2020). These projects, though not targeting eulachon habitat, are likely to improve material fluxes to the mainstem and thus better support the production of phytoplankton, the primary food source for eulachon in the lower Columbia River. These benefits will increase as restored habitat area accrues over time and habitat quality matures.

2.15.3.1.4 Research, Monitoring, and Evaluation Activities

The Action Agencies' RME program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline section, primarily from the capture and handling of adult eulachon, is likely to continue at a similar or reduced level. However, because eulachon numbers in the lower Columbia River vary so widely from year to year, we estimate that, on average, the following number of eulachon will be affected each year:

- Up to 21,000 adult eulachon will be handled and 200 will be killed during RME activities such as towing a midwater trawl with a PIT-tag detector in place of a cod end, or beach seining for salmon. No juvenile eulachon will be handled or killed.

The combined observed mortality associated with these elements of the RME program will, on average, affect less than 1 percent of the adult eulachon run and an unknown, but probably very small proportion of the outmigrating juveniles in any given year. Given that these RME programs allow the Action Agencies and NMFS to continue evaluating the effects of CRS operations (including facilities modifications and mitigation actions), the effects of the RME programs on abundance are acceptable and warranted.

We expect very few eulachon to be encountered during April to July electrofishing operations conducted under the NPMP. Spawning is mostly completed by the end of March and out-going juveniles leave freshwater by mid-April (NMFS 2017l). Further, electrofishing operations are limited to shoreline habitat less than 3-m deep, which is a small portion of the water column where eulachon are likely to be present.

2.15.3.2 Effects to Critical Habitat

The PBFs of freshwater spawning and incubation sites, freshwater and estuarine migration corridors are essential for conservation because eulachon cannot successfully spawn and produce offspring without this habitat; the habitat allows adult fish to swim upstream to reach spawning areas, allows juvenile fish to proceed downstream to reach the ocean, and provides abundant forage species and suitable water quality. The lower Columbia River below Bonneville Dam constitutes a significant portion of the critical habitat designated for this DPS.

The proposed action will affect the PBFs of eulachon critical habitat, as described in Table 2.15-4. The implementation of the flexible spring spill operation will continue to alter water quality (reduced spring turbidity levels), water quantity (seasonal changes in flows and consumptive losses resulting from use of stored water for agricultural, industrial, or municipal purposes), water temperatures, and water velocity (reduced spring flows and increased cross-sectional areas of the river channel). Table 2.15-4. Effects of the proposed action on the physical and biological features (PBFs) of designated critical habitat for the southern DPS of eulachon.

Table 2.15-4. Effects of the proposed action on the physical and biological features (PBFs) of designated critical habitat for the southern DPS of eulachon.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning and incubation sites	Continued effects of reduced sediment transport, altered hydrograph, altered water temperature regime. Magnitude of effects on the conservation value of the water quality and water quantity PBFs is unknown. Fallback of any adult eulachon that ascends Bonneville Dam after the increased spring spill begins on April 10 is likely to be via the spillway. Magnitude of effect on the conservation value of the safe passage PBF is unknown because we do not have passage survival information for the different routes (spillway, bypass, corner collector, turbines).
Freshwater and estuarine migration corridors	Ongoing floodplain reconnection projects expected to improve material fluxes and thus to better support phytoplankton production in the lower river (adequate forage).

2.15.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Environmental Baseline section.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat and mainstem habitat for eulachon. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation), various stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will improve conditions for eulachon.

NMFS has also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and are included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations. Attaching LED lights to the fishing lines of ocean shrimp trawls appears to greatly reduce the number of eulachon bycatch for this commercial fishery (Hannah et al. 2015, Lomeli et al. 2018).

Overall, we anticipate that projects to restore and protect habitat will result in a beneficial effect on eulachon compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on eulachon in the action area.

2.15.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.15.5.1 Species

2.15.5.1.1 Status

The southern DPS of eulachon comprises fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. Four subpopulations—the Klamath River, the Columbia River, the Fraser River, and the British Columbia coastal rivers—are considered in NMFS' recovery plan as a minimum set of "populations" that are needed to meet biologically based (abundance, productivity, spatial distribution, and genetic and life-history diversity) and threats-based delisting criteria (NMFS 2017l).

Presently, most eulachon production south of the U.S.–Canada border originates in the Columbia River basin, including the Columbia, Cowlitz, Grays, Kalama, Lewis, and Sandy Rivers (Gustafson et al. 2010). Historically, eulachon were occasionally reported to spawn in tributaries as far upstream as the Hood River (Oregon) and the Klickitat River (Washington) (NMFS 2017l). Since Bonneville Dam was completed in 1937, there have been occasional observations of eulachon at, or even above (passing through the ship locks), the dam in years when eulachon were highly abundant (NMFS 2017l).

NMFS' most recent status review affirmed that the southern DPS of eulachon should retain its designation of threatened (NMFS 2016j). Starting in 1994, southern DPS eulachon experienced an abrupt decline in abundance throughout its range. Eulachon abundance in monitored rivers improved in the 2013 to 2015 return years, but recent poor conditions in the northeastern Pacific Ocean appear to have driven sharp declines in the river systems in 2016 and 2017. No reliable fishery-independent, historical abundance estimates exist for eulachon. From 2000 to 2019, the mean spawning stock biomass estimates in the Columbia River ranged from a low of about 783 thousand fish in 2005 to a high of nearly 186 million fish in 2014, with a mean estimate of 46.7 million fish in 2019. Spawning stock biomass estimates in the Fraser River (1995–2019) ranged from a low of about 110 to 150 thousand fish in 2010 to a high of about 42 to 56 million fish in

1996. Fishery-independent estimates are not available for the Klamath River or British Columbia coastal rivers (NMFS 2017l).

Migrating to spawning grounds as adults are associated with higher tides and water temperatures ranging from 40 to 50°F, and can occur as early as November or as late as June, with peak spawning typically occurring sometime between January through March. Fertilized eggs drift downstream, adhere to sand and small gravels, and typically hatch in 3 to 8 weeks, depending on water temperatures. Larvae are transported downstream, where they rear for an unknown amount of time before moving to the ocean, where they usually remain for 2 to 5 years before returning to spawn.

Climate change impacts on ocean conditions are rated as the highest threat to the persistence of eulachon subpopulations, followed by bycatch in offshore shrimp fisheries (NMFS 2017l). Dams and water diversions, climate change impacts on freshwater habitat, predation, water quality, shoreline construction, and dredging were all rated as moderate impacts.

Eulachon abundance appears strongly related to ocean conditions, and thus this species is considered extremely vulnerable to climate change. The recovery plan (NMFS 2017l) identifies recovery actions to be implemented, including estuary and freshwater habitat (e.g., water quality) actions and changes to the shrimp fishery. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and Federal parties across two states be coordinated at multiple levels.

2.15.5.1.2 Environmental Baseline

Habitat in the action area is degraded by numerous human activities: the development and operation of water storage and diversion facilities and mainstem hydroelectric facilities, shoreline development, rural development, urbanization, dredging and toxic contamination.

Tributary habitat is degraded and continued urbanization and habitat degradation in combination with the potential effects of climate change (discussed further below) also present risks. Reduced or lost habitat complexity, connectivity, quantity and quality (including water quality and toxics) in lower river tributaries and along the estuary floodplain remains a specific area of concern. The series of dams and reservoirs have also blocked natural sediment transport; the delivery of suspended particulate matter to the lower river and estuary has been reduced and has altered the development of habitat along the margins of the river

In the opinion for the 2018 to 2027 *U.S. v. Oregon* Management Agreement (NMFS 2018a), which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin, NMFS concluded that releases of hatchery salmon and steelhead are not expected to overlap with emerging eulachon juveniles in the lower Columbia River because the emergence and outmigration of juvenile eulachon generally occurs in January through March, before hatchery juveniles reach the lower mainstem Columbia River in April and May. Since 2014, Washington and Oregon have adopted limited-opportunity recreational and commercial fishery on eulachon in the Columbia River and the Cowlitz and Sandy Rivers (TAC 2017). Encounters of eulachon in Columbia River salmon fisheries would be extremely unlikely given the differences in temporal distribution and gear characteristics. The recovery plan rates the level of threat for fisheries in the Columbia River as low (NMFS 2017l).

Rearing and migration conditions for eulachon in the lower Columbia River and estuary may have been affected by the construction of upstream water storage facilities; diversions for irrigation, municipalities, etc.; and their coordinated operation (basinwide water management activities). On average, these activities have generally increased flows in the lower Columbia River and estuary from November through March, during eulachon spawning and incubation, and decreased flows in April through June, during the outmigration period. However, no mechanisms of effect have been observed.

The status of eulachon is likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycles. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater, and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including eulachon. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics, as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of eulachon, and how that relationship interacts with other variables throughout the eulachon life cycle, will likely be an important area of future research.

2.15.5.1.3 Cumulative Effects

When evaluating the effects of the action, those effects must be taken together with the effects on eulachon of future state or private activities, not involving Federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on eulachon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts led by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more region-wide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

2.15.5.1.4 Proposed Action

The effects of CRS operations on populations originating in subbasins downstream of Bonneville Dam are limited to the effects of flow management and marginally increased exposure to higher TDG levels during migration and rearing in the Columbia River, including the estuary. Reduced flows from May through July will be an ongoing effect of CRS operations as proposed. While the overall effects on adults and larvae are unknown, they could potentially be positive from December through March (increased flows) and potentially negative in May and June (decreased flows) for those eulachon larvae migrating/drifting through the estuary and plume in these periods. Other impacts, such as alterations in sediment transport, may also affect southern DPS eulachon, but we have no data to quantify the magnitude or scale of those impacts.

For adults that reach Bonneville Dam in high-abundance years, this project remains a substantial barrier to upstream migration to a small number of tributaries where spawning historically may have occurred. While many individual adults (and their surviving progeny) may be affected, reduced survival of adults (upstream passage and fallback) or their progeny are likely not substantially limiting the abundance and productivity in subpopulations in the Columbia River.

As a result of the proposed action, spring spill levels at Bonneville Dam would be limited to 125 percent total dissolved gas, or 150 kcfs, whichever is lower. Adult eulachon will not be present during the spring spill period and therefore will not be affected by elevated TDG. Juvenile eulachon that are still in the mainstem during this period will be exposed, but there is no information on the risk of GBT for this species.

The Action Agencies will continue to fund predator control activities and estuary habitat improvements, and modify operations to improve salmon survival. The implementation of the CRS mitigation and enhancement programs will continue to reduce long-term impacts and may support a small improvement in the status for eulachon. The pikeminnow program will likely provide some small productivity benefit at the population scale. The estuary program is anticipated to improve the productivity of phytoplankton in the lower river, the primary food source for larval eulachon.

As a general matter, the effects of the proposed action are very similar to a continuation of the same effects caused by the current operations and maintenance of the CRS, as well as the associated measures implemented to avoid, minimize or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to southern DPS eulachon or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary that will accrue over time.

2.15.5.1.5 Integration and Synthesis

The southern DPS of eulachon is at very low levels throughout their range. The “population” in the Columbia River Basin is one of four management units. Climate change effects and losses (bycatch) in ocean fisheries are thought to be the most important limiting factors for eulachon. Dams and water diversions, climate change impacts on freshwater habitat, predation, water quality, shoreline construction, and dredging were all rated as moderate impacts.

Climate change could affect productivity in tributary habitat (and in the mainstem Columbia River) through changes in flow and increasing temperatures, which could affect the spawn timing, incubation timing, and rearing and migration timing of eulachon. However, it is unclear how changes in the timing of specific life-history stages would affect survival, if at all, especially in the next 15 years.

Most importantly, the proposed continuation of the estuary habitat program should continue to effectively conserve existing productive rearing habitat, restore degraded habitat, and provide access to currently disconnected floodplain habitat—actions which may improve the survival of eulachon larvae as they transition from the estuary to the ocean.

Overall, the effects of the action are not expected to meaningfully reduce population parameters for the southern DPS of eulachon beyond the current environmental baseline and could result in some improvements, especially as a result of estuary habitat restoration actions, over the next 15 years.

The proposed action will not result in meaningful reductions to eulachon reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, we find that the proposed action is not likely to meaningfully reduce the number, reproduction or distribution of southern DPS eulachon in the wild. Furthermore, the proposed action is consistent with actions called for in the 2016 Recovery Plan, and should not result in meaningful reductions to eulachon reproduction, numbers, or distribution that would impede the ability of southern DPS of eulachon to recover within the time frames considered in the recovery plan.

2.15.5.2 Critical Habitat

Critical habitat for the southern DPS of eulachon encompasses 16 rivers in California, Oregon, and Washington. This includes the lower Columbia River and nearshore and offshore marine foraging habitat with water quality and prey that support juvenile and adult survival. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns and habitat quality.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for eulachon. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative) on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of Federal, state, and local agencies; tribes; and other stakeholders. Restoration activities addressing access to the historical estuarine floodplain are improving the baseline condition for the spawning and incubation PBF.

Continued operation of the CRS will impact the timing of flows in the lower Columbia River. Increased levels of TDG during the spring spill period will increase TDG levels within Bonneville Dam’s reservoir and for at least 35 miles downstream. However, we do not know if the proposed increase in spill and TDG will have substantive negative effects on the PBFs that support eulachon spawning and incubation because most spawning will be complete before the onset of spring spill. Increased flows could also diminish the value of incubation sites in the lower Columbia River. The estuary habitat restoration program will reconnect floodplains and provide additional forage and water quality at the project scale; these benefits will accrue at the designation scale over time.

Considering the ongoing and future effects of the environmental baseline and cumulative effects and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of eulachon.

2.15.6 Conclusion

After reviewing and analyzing the current status of the southern DPS eulachon and its critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS’ biological opinion that the proposed action is not likely to jeopardize the continued existence of the southern DPS eulachon or destroy or adversely modify its designated critical habitat.

2.16 “Not Likely to Adversely Affect” Determination

On January 23, 2020, NMFS received the Action Agencies’ request for a written concurrence that the ongoing operation and maintenance of the CRS, and associated non-operational measures to offset adverse effects to listed species, are not likely to adversely affect (NLAA) the southern DPS of North American green sturgeon (*Acipenser medirostris*) and critical habitat designated under the Endangered Species Act (ESA), and the Southern Resident killer whales (SRKW) (*Orcinus orca*) and their designated critical habitat. NMFS prepared this response to the Action Agencies’ request pursuant to section 7(a)(2) of the ESA, implementing regulations at 50 CFR 402, and agency guidance for preparation of letters of concurrence.

2.16.1 Southern Resident Killer Whales

The Southern Resident killer whale DPS (SRKW DPS or Southern Residents) was listed as endangered on February 16, 2006 (70 FR 69903). A recovery plan was completed in 2008 (NMFS 2008e). Critical habitat in inland waters of Washington for the SRKW DPS was designated on November 29, 2006 (71 FR 69054). On September 19, 2019, NMFS (2019h) proposed to revise the critical habitat designation by adding six additional areas along the U.S. West Coast (84 FR 49214). In the most recent 5-year status review, NMFS (2016k) evaluated information on the status of the DPS including threats and research results and publications and concluded that SRKWs should remain listed as endangered. Southern Residents are not directly affected by the implementation of the proposed action. However, there are potential effects to their prey base. The analysis below examines the potential for exposure (overlap in time and space with Southern Residents and their prey base), and the significance of that exposure.

The SRKW DPS consists of three pods (J, K, and L) that inhabit coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008e, Hanson et al. 2013, Carretta et al. 2019). During the spring, summer, and fall months, the whales spend a substantial amount of time in the Salish Sea (the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound; Bigg 1982, Ford et al. 2000, Krahn et al. 2002, Hauser et al. 2007, Hanson et al. 2010a). Although all three pods generally remain in the Georgia Basin through October, they make frequent trips to the outer coasts of Washington and southern Vancouver Island, and are occasionally sighted as far west as Tofino and Barkley Sound (Ford et al. 2000, Hanson et al. 2010a). Although these movements are somewhat predictable, there can be large inter-annual variations in arrival time and the number of days present in inland waters from spring through fall. In recent years, Southern Residents have arrived in inland waters later and have been present for fewer days (Hanson and Emmons 2010, Olson et al. 2018), implying that the time spent in coastal waters is increasing.

By late fall, all three pods are seen less frequently in inland waters. Hanson et al. (2010b, 2013) and NMFS (2019h) report several sightings and acoustic detections of Southern Residents off the Washington and Oregon coasts in the winter and spring. Deployments of satellite-linked tags have provided more data on movements, showing that the K and L pods use the coastal waters of

Washington, Oregon, and California during non-summer months. Detection rates of K and L pods on passive acoustic recorders were highest off the mouth of the Columbia River and Westport, Washington, in March (Hanson et al. 2013). The J pod has only been detected on one of seven passive acoustic recorders positioned along the outer coasts of Washington, Oregon, and California (Hanson et al. 2013) and off Swiftsure Bank between Vancouver Island and Washington, (Riera et al. 2019). The limited range of the sightings and acoustic detections of J pod whales in coastal waters, the lack of coincident occurrence during sightings of the K and L pods, and the results from satellite tagging in 2012 to 2016 (Hanson et al. 2017, 2018) indicate that the J pod’s occurrence along the outer coast (Riera et al. 2019) is limited compared to its use of inland waters, especially in the northern Georgia Strait.

Although Southern Residents consume a variety of fish (22 species) and one species of squid (Ford et al. 1998, 2000, 2016; Ford and Ellis 2006, Hanson et al. 2010b), salmon are their primary prey. Their dietary habits are the subject of ongoing research, including direct observations, analysis of scales and tissues sampled from prey remains, and the collection and analysis of fecal material. Scale and tissue samples collected in inland waters of Washington and British Columbia indicate a high percentage of Chinook salmon from local populations (the Fraser River and Puget Sound) during May to September (Hanson et al. 2010b).

Although we have relatively little data for Southern Residents during winter, Chinook salmon appear to remain the most important component of the diet for the K and L pods that occupy outer coastal waters during this period (Hanson et al., in review). Before 2013, only three prey samples from feeding events had been collected on the U.S. outer coast, but in 2013 to 2016, Hanson et al. (in review) used satellite tags to locate and follow the whales to obtain prey and fecal samples. Chinook salmon were again the dominant prey. Southern Residents from the K and L pods occur off the Columbia River in March (Hanson et al. 2013), emphasizing the importance of fish from Mid/Upper Columbia River and LCR spring-run Chinook salmon populations in the diet during later winter and early spring (Hanson et al., in review).

2.6.1.1 Demographics of the Southern Resident Killer Whale DPS

NMFS contracts with the Center for Whale Research to conduct an annual census of the SRKW population. The population totaled 73 individuals as of December, 2019 (Center for Whale Research 2020a). However, one whale is now missing and presumed dead (Center for Whale Research 2020b), a decline from the 81 whales reported as of September 2013 (NMFS 2014a). The NWFSC continues to evaluate changes in fecundity and mortality rates. They updated the population viability analysis developed for the 2004 status review for Southern Residents (Krahn et al. 2004). The data project a downward trend in population size over the next 50 years, with increased uncertainty around the projected population size further out in time, assuming all of the model parameters (e.g., fecundity and death rates) remain the same (Figure 2.16-1). This projection of a downward trend is in part driven by the changing age and sex structure of the population, but is also related to the relatively low fecundity rate observed during 2011 to 2016 (NMFS 2016k).

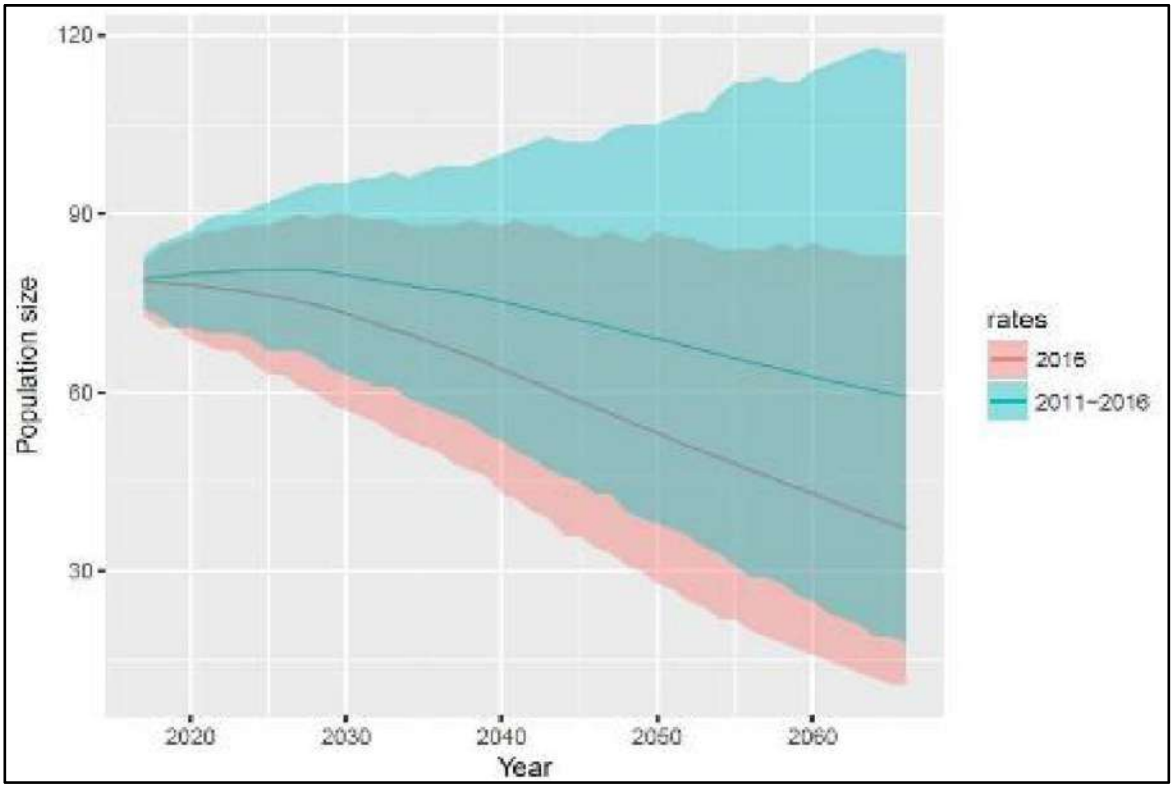

Figure 2.16-1. Southern Resident killer whale population size projections from 2016 to 2066 using two scenarios: 1) projections using demographic rates held at 2016 levels, and 2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar to those in 2016, whereas the blue represents the scenario with future rates being similar to 2011 to 2016 (NMFS 2016k).

When reproduction and fecundity of the SRKW DPS were studied, Ford et al. (2018) suggested that the DPS’s small size and insularity have resulted in inbreeding depression, which could affect fitness. They found that two adult males had sired 52 percent of the sampled progeny that had been born since 1990. Based on the pedigree, four sampled offspring were the result of an inbred mating, two between parent and offspring, one between paternal half-siblings, and one between an uncle and half-niece. There is no evidence to date that the survival or fecundity of these individuals is lower than normal, but they presented some evidence of inbreeding depression. They found no evidence of inbreeding avoidance within the DPS, but the late age of breeding success that has been observed for males may indirectly limit the opportunity for parent/offspring mating.

“Demographic stochasticity” constitutes another risk to viability. That is, because the DPS is made up of a single, small population, what otherwise would be random patterns of birth and deaths among individuals can have “outsized” effects on its fate. The smaller the population, the more each individual’s reproductive success or failure affects its growth or decline (i.e., Coulson et al. 2006). Wasser et al. (2017) reported that pregnancy hormones (progesterone and testosterone) could be detected in Southern Residents’ feces; their analysis indicated several miscarriages, particularly in late pregnancy. Based on these data, up to 69 percent of the detected pregnancies did not produce a documented calf (Wasser et al. 2017). Recent aerial imagery corroborates previous notions that Southern Residents have high rates of pregnancy loss (Durban 2020). The congruence between the rate of loss estimates from fecal hormones and aerial photogrammetry suggests the majority of the loss is in the latter half of pregnancy when photogrammetry can detect anomalous shape after several months of gestation (Durban et al. 2016).

2.6.1.2 Limiting Factors

Several factors identified in the recovery plan for SRKW (NMFS 2008e) may be limiting recovery. The recovery plan identified three major threats including: 1) the quantity and quality of prey, 2) toxic chemicals that accumulate in top predators, and 3) impacts from sound and vessels. Oil spills and disease as well as the small population size (discussed above) are also risk factors. Of these, prey availability may be affected by the proposed action. Lacy et al. (2017) constructed a population viability assessment model that considered the sublethal effects and cumulative impacts of threats such as contaminants, acoustic disturbance, and prey abundance. The effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Lacy et al. (2017) suggested that, for the Southern Resident population to reach the 2.3 percent growth rate needed for recovery, Chinook abundance would need to be increased by 15 percent. However, their model relied on older published correlation between population size and vessel disturbance, contaminants, and prey abundance, assumed that these correlations represented cause-and-effect relationships, and projected the future size of the SRKW DPS under the assumption that these relationships would remain constant over time. This approach was previously criticized by Hilborn et al. (2012), a panel of experts that cautioned against overreliance on correlative studies, particularly relationships between Chinook salmon availability and the size of the DPS. In critiquing a biological opinion on the 2010-2014 Puget Sound Chinook Harvest Resource Management Plan, Hilborn et al. (2012) wrote that not all members of the panel were convinced that poor body condition was necessarily an indicator of nutritional stress (due to low availability of prey) in Southern Residents as compared to some other factor (disease, organ malfunction) that might lead to reduced or less successful feeding and thereby generate poor body condition. Thus, the expert panel cautioned against drawing conclusions based on correlation without evidence for the underlying mechanisms. Given the above, there does not appear to be sufficient information to conclude that prey availability is the dominant limiting factor.

NMFS and WDFW (2018) identified the priority Chinook salmon stocks for which actions could be implemented to increase the availability of prey for Southern Residents. The report’s prioritization framework considered three factors: whether the potential prey item had been observed in the whales’ diet, whether it had been observed consumed by individuals with reduced body condition or during winter when the diet is relatively diverse (i.e., including chum salmon, halibut, lingcod, and big skate), and the degree of spatial and temporal overlap between the prey item and the whales. Based primarily on the spatio-temporal overlap scores, the highest-priority Chinook salmon stocks were fall run Chinook salmon from Northern and Southern Puget Sound. Next on the list were fall runs from the lower Columbia River and the Strait of Georgia, followed by fall runs from the upper Columbia and Snake Rivers, spring runs from the Fraser River, and spring runs from the lower Columbia River. Snake River spring/summer Chinook salmon and spring Chinook salmon from Northern Puget Sound populations were also among the priority stocks for prey resource enhancement, but with lower spatio-temporal overlap scores. Therefore, based on data reported in Hanson et al. (in review) and the spatio-temporal overlap scores in NMFS and WDFW (2018), while in coastal waters, Southern Residents prey on salmonids that may be affected by the proposed action.

2.16.1.3 Proposed Action and Action Area

The proposed action is described in Section 1.3. The action area for effects on the SRKW DPS includes all areas off the Pacific Coast where salmonid species from the Columbia River that are affected by the projects or programs of the CRS are available as prey for Southern Residents. This area encompasses the whales’ entire coastal range from the mouth of the Columbia River and its plume, south as far as central California (Weitkamp 2010, Shelton et al. 2019) and north as far as Southeast Alaska (NMFS 2008d, Hanson et al. 2013, Carretta et al. 2019). Small numbers of Chinook salmon from the Columbia River also enter the Salish Sea (Weitkamp 2010, Shelton et al. 2019).

2.16.1.3.1 Action Agencies’ Effects Determinations

The Action Agencies determined that the effects of the CRS program are not likely to adversely affect Southern Residents or their designated critical habitat or proposed critical habitat in coastal waters (Section 3.5.1.2 in BPA et al. 2020).

2.16.1.3.2 Effects of the Action

The proposed action may affect Southern Residents through effects to their primary prey in coastal waters during winter and early spring. This analysis focuses on effects to Chinook salmon availability because the best available information indicates that Chinook salmon are the Southern Residents’ primary prey during this time period. The principal pathways for negative effects of the proposed action on the survival of individuals and the abundance and productivity of the listed salmon populations are discussed in Sections 2.2 through 2.14:

- Reduction in juvenile reach survival through the hydrosystem (varying with smolt size, migration timing, and point of entry into the hydrosystem).
- Reduction in adult survival through the hydrosystem (varying with life history characteristics such as run timing and location of spawning tributaries).

These pathways for negative effects apply to both natural- and hatchery-origin fish and to juveniles and adults from unlisted populations, which also constitute prey for Southern Residents (Ford et al. 2016, Hanson et al., in review). For purposes of determining whether the SRKW DPS is likely to be adversely affected by a reduction in prey base caused by the proposed action, it is not necessary to precisely quantify the mortality resulting from the hydrosystem operations (as distinguished from other causes), so long as it can be reasonably concluded that the decrease in the prey base for Southern Residents resulting from hydrosystem operations is less than the increase in the prey base resulting from the hatchery programs funded by the action agencies.

Contribution of CRS Hatchery Production to the SRKW Prey Base

In the 2008/2014 and 2019 biological opinions, we stated that the operation and configuration of the FCRPS (i.e., the CRS) causes mortality of migrating juvenile Chinook salmon, which in turn results in fewer adult Chinook salmon in the ocean and reduced prey availability for killer whales (NMFS 2008a, 2010, 2014a, 2019c). We also determined that the Action Agencies' hatchery production more than offset losses to the killer whale prey base. That analysis relied on fisheries catch and escapement data through 2005, which indicated that approximately 3.5 million adult Chinook salmon were available as prey in the coastal range of Southern Residents (Table 2 in NMFS 2008d). As described more fully below, we continue to conclude that the proposed action is not likely to adversely affect the SRKW DPS because increased prey availability through CRS-funded hatchery production more than offsets any negative effects on SRKW prey base caused by the proposed hydrosystem operations and maintenance.

CRS-funded hatchery production is likely having a far greater positive effect on the number of adult Chinook salmon available to Southern Residents than the negative effect of hydrosystem operations on adult Chinook salmon abundance. For example, Camacho et al. (2019b) provides estimates of the abundance of natural origin Snake River spring/summer Chinook salmon smolts arriving at Lower Granite Dam. From 2009 to 2018 (the most recent 10 years for which empirical estimates, not model projections, are available), an average of about 1.2 million natural origin fish smolts arrived at Lower Granite Dam (ranging from about 0.5 to 1.7 million smolts). In comparison, CRS-funded hatchery production in the Snake River Basin will average about 3.8 million spring and summer Chinook salmon smolts annually. Similarly, Perry et al. (2020) estimated that the median capacity of Snake River fall Chinook salmon spawning areas upstream of Lower Granite Dam was about 1.25 million smolts (90 percent confidence interval of 0.98 to 1.62 million smolts). CRS-funded hatchery production in the Snake River Basin will average about 4.4 million annually. Thus, even though more than half of the natural-origin smolts arriving at Lower Granite Dam may die during migration to the ocean as a result of the operation and maintenance of the CRS, natural sources of mortality such as predation and disease, and factors associated with the existence of the dams; the number of hatchery-origin fish released from CRS funded hatchery programs more than offsets those losses.

Steelhead also were present in scale/tissue and fecal samples collected in coastal waters, but comprised a much lower percent of the fish that could be identified (i.e., less than 20 percent in both cases). The Action Agencies also contribute funding for steelhead production as mitigation for the CRS (e.g., Table B-6 in the 2018 to 2027 *U.S. v. Oregon* Management Agreement shows that BPA funds the production of more than 300,000 steelhead smolts at the Clearwater Fish Hatchery as CRS mitigation). In addition, although we lack basin-wide estimates of all natural origin salmonid smolt production (e.g., UCR salmonids), the effects of hydrosystem on those fish are significantly less than for SR salmonids (e.g., fewer CRS dams passed in general, with very limited exposure to hydrosystem operations in the case of LCR salmonids). We also consider the increased availability of Chinook salmon a conservative estimate of the overall effects of CRS operations and maintenance because Chinook dominate the prey found in the diet studies discussed above and are much less numerous than other salmonids and fish species. Hanson et al. (in review) identified Chinook salmon as an important prey item, averaging about 69 percent of the diet based on fecal samples and 80 percent based on scales and tissues collected from predation events in coastal waters during the January through April time period. Therefore considering the diversity of run types (e.g., fall, summer, and spring-run Chinook salmon, and steelhead) and the magnitude of CRS-funded hatchery production, any effects to the SRKW DPS due to reduced prey availability of these other species are insignificant.

The large contribution of adult Chinook salmon to the SRKW DPS prey base made by CRS-funded hatcheries can also be seen by applying the production schedules and range of SARs we used in NMFS (2018a) to this analysis. We estimate that Action Agency funding for hatchery production to offset losses due to the CRS will result in more than 143,000 adult equivalents of Chinook salmon returning to Bonneville Dam each year (Table 2.16-1), including more than 51,000 spring-run and 86,000 fall-run fish. There is no information to suggest that the timing of these runs and their availability to SRKWs will be altered by the proposed action. Despite the lack of prey and fecal samples from coastal waters during summer and fall, fall-run Chinook salmon are known to overlap with Southern Residents off the Washington coast during this period and are considered priority stocks for enhancement measures (NMFS and WDFW 2018). All of these fish will have returned to Bonneville Dam after exposure to coastal and lower river fisheries and after they are available to Southern Residents, and will be in addition to natural-origin returns. More than 143,000 Chinook salmon is a meaningful number of fish returning to the mouth of Columbia River that are available as prey for Southern Residents because of CRS funding.

Table 2.16-1. Estimated adult equivalents for Chinook salmon available to Southern Resident Killer Whales in coastal waters based on hatchery production for CRS mitigation under the 2018 to 2027 *U.S. v. Oregon* Management Agreement. Adult equivalents were calculated as the product of hatchery releases for CRS mitigation and smolt-to-adult returns (SARs) at Bonneville Dam. Source: Jording (2020).

Chinook Run Type	CRS-funded Hatchery Releases	SAR	Adult Equivalents at Bonneville Dam
Spring	12,895,000	0.0040	51,580
Summer	2,280,330	0.0024	5,473
Fall	28,890,000	0.0030	86,670
			143,723

Other elements of the proposed action (e.g., flexible spring spill, continued habitat improvements) should reduce the amount of negative effects of the CRS that would need to be offset by hatchery production. Although life-cycle models indicate that ocean conditions are likely to suppress adult returns for Snake River spring/summer Chinook salmon (e.g., Section 2.2.3.1.12) and presumably, other stream-type Chinook salmon populations in the Columbia

River Basin, this is not an effect of the proposed action, and the hatchery production will also reduce the magnitude of adverse changes to prey availability for Southern Residents resulting from climate change.

The above analysis is based on the Action Agencies’ proposal to fund the operations and maintenance of safety-net and conservation hatchery programs and their respective independent congressionally-authorized hatchery mitigation responsibilities over the 15-year implementation period (2021 to 2036). The Action Agencies indicated the production levels associated with congressionally-authorized hatchery mitigation objectives will continue, at minimum, to be consistent with levels previously analyzed by NMFS in the hydrosystem consultations in 2008, 2014, and 2019. Changes to the anticipated levels of hatchery production could trigger a need to reassess the effects of the proposed action.

Prey Quality

We also considered whether CRS-funded hatchery production is likely to have reduced prey quality for Southern Residents. For example, Ohlberger et al. (2018) found that, since the late 1970s, the proportions of older age classes of Chinook salmon have decreased across most of the eastern North Pacific Ocean. The length-at-age of older fish (4- and 5-ocean, and to some extent 3-ocean) declined while that of younger fish, especially those from hatchery stocks, increased during the same period. Smaller length-at-age would reduce the energetic intake of Southern Residents for each capture, requiring additional effort to obtain the same level of nutritional benefit. However, simulations described in Ohlberger et al. (2019) indicate that the decline in mean size could have resulted from the selective removal of large fish by harvesters, resulting in an evolutionary shift toward faster growth and earlier maturation. They further suggest that the main impact of fishing on the size and age composition of Chinook salmon occurred before the 1970s and that these size declines likely continued with the increased removals by fisheries and marine mammal predators, specifically Southern Residents and the expanding populations of North Pacific killer whales inhabiting more northerly waters. Without increasing predation pressure, average sizes of older Chinook salmon should have partly recovered with reductions in harvest during the past 40 to 50 years (Ohlberger et al. 2019).

With respect to the effect of hatchery practices on Chinook salmon size and therefore Southern Resident nutritional intake per unit of hunting effort, Ohlberger et al. (2019) noted that wild populations of Chinook salmon in western Alaska that were not exposed to hatchery introgression or potential competition with hatchery stocks, such as Chinook salmon in western Alaska, experienced similar declines in length-at-age for older fish. Thus, it is not likely that smaller length-at-age, which could increase the hunting effort required for Southern Residents to achieve an adequate nutritional intake, is a negative effect of Action Agency-funded hatchery production. For these reasons, any potential effect on prey quality is insignificant.

Summary—Effects to SRKWs

The status of the SRKW DPS is on a declining trend, which is likely due to a combination of the three top limiting factors: prey availability, vessel noise and disturbance, and toxic contaminants.

The proposed action has the potential to affect prey availability through negative effects on the direct survival of juvenile and adult salmonids through the hydrosystem and the latent mortality of juveniles, including Chinook salmon, which is the whale’s predominant prey species in the action area. However, any effects to SRKW DPS prey base are insignificant or extremely unlikely because the CRS-funded hatchery production more than offsets any adverse effects of CRS operations and maintenance. In addition, other elements of the proposed action (e.g., flexible spring spill, continued habitat improvements) should reduce the amount of negative effects that would need to be offset. Similarly, there is no evidence to suggest an impact to prey quality from CRS- funded hatchery production, confirming that potential effect is insignificant.

2.16.1.3.3 Critical Habitat

NMFS designated critical habitat for the SRKW DPS on November 29, 2006 (71 FR 69054) in three specific areas: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands, 2) Puget Sound, and 3) the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified the following PBFs as essential to conservation: 1) water quality to support growth and development, 2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth, and 3) passage conditions to allow for migration, resting, and foraging. These areas are within the action area for this consultation because small numbers of Chinook salmon from the Columbia River also enter the Salish Sea (Weitkamp 2010, Shelton et al. 2019).

NMFS proposed to revise the critical habitat designation for the SRKW DPS by designating six new areas along the west coast of the U.S. based on SRKW use and habitat features (84 FR 49214). The new areas proposed for designation cover 15,626.6 square miles of marine waters between the 20-foot and 656-foot depth contours from the U.S. international border with Canada south to Point Sur, California. In the proposed rule, NMFS states that the “proposed areas are occupied and contain physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection.” The three PBFs essential for conservation in the 2006 critical habitat designation were also identified as essential for conservation in the six new areas along the U.S. West Coast.

The proposed action may affect the PBF of prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth in the action area. The mechanism by which the proposed action could have a negative effect on the functioning of this PBF would be through the mortality of juvenile and adult Chinook salmon due to passage through the hydrosystem, thus limiting the availability of Chinook salmon as prey for Southern Residents in coastal waters and the Salish Sea. However, as described in Section 2.16.1.1.2, the Action Agencies will continue to fund the Chinook salmon hatcheries with production levels that provide substantial numbers of adult equivalents to offset losses caused by the CRS, and there is no evidence to suggest a decrease in quality or availability of prey to SRKWs.

For these reasons, and as discussed more fully above, we expect any negative effect of the proposed action on the functioning of prey species quantity, quality, and availability to be undetectable and therefore insignificant.

2.16.1.3.4 Conclusion

Based on this analysis, NMFS concurs with the Action Agencies that the proposed action is not likely to adversely affect Southern Residents or their designated and proposed critical habitat.

2.16.2 Southern DPS of Green Sturgeon

On April 7, 2006, NMFS listed the southern DPS of North American green sturgeon (herein referred to as southern DPS green sturgeon or sDPS green sturgeon) as a threatened species under the ESA (71 FR 17757, April 7, 2006). This determination was based on the fact that the Sacramento River basin contains the only known sDPS spawning population, information suggesting population decline, and habitat loss and degradation in the Sacramento River basin. Since the listing of the DPS, a number of habitat restoration actions within the Sacramento River basin have occurred, and spawning has been documented in the Feather and Yuba Rivers (Seesholtz et al. 2015, Beccio 2018), but many significant threats have not been addressed. Currently, the majority of sDPS green sturgeon spawning occurs within a single reach of the mainstem Sacramento River, placing the species at increased risk of extinction due to stochastic events. NMFS completed a 5-year review in 2015 (NMFS 2015d) and published a final recovery plan for this DPS (NMFS 2018c).

Green sturgeon are broadly distributed in nearshore marine areas from Mexico to the Bering Sea. Green sturgeon are commonly observed in bays, estuaries, and sometimes the mainstem lower elevation reaches of non-natal rivers along the west coast of North America, including the lower Columbia River estuary (NMFS 2015d). Green sturgeon consist of two DPSs that co-occur throughout much of their range, but use different river systems for spawning. All naturally spawned populations of green sturgeon originating from coastal watersheds south of the Eel River in Humboldt County, California (known spawning populations are in the Sacramento River system) are considered part of the southern DPS. The northern DPS consists of populations originating from coastal watersheds north of, and including, the Eel River (known spawning populations in the Eel, Klamath, and Rogue Rivers). The northern DPS is not listed as threatened or endangered, but is a NMFS Species of Concern.

Mora et al. (2018) used acoustic telemetry and dual-frequency identification sonar to generate an adult sDPS green sturgeon abundance estimate of 2,106. They have also generated a subadult sDPS green sturgeon population estimate of 11,055 by applying a conceptual demographic structure to the adult population estimate. These estimates do not include the number of spawning adults in the lower Feather or Yuba rivers, where green sturgeon spawning has been confirmed (Seesholtz et al. 2014).

No hatchery programs exist for the green sturgeon. Southern DPS green sturgeon have been confirmed to occur in the Willamette/Lower Columbia, Oregon Coast, and Southern

Oregon/Northern California Coasts recovery domains. In many Oregon coastal systems, inadequate data exist to confirm the sDPS’s presence, but presence has been established in Coos Bay, Winchester Bay (Umpqua River), Yaquina Bay, Nehalem Bay, and the Columbia River estuary (NMFS 2010).

Research conducted and published since 2006 confirms and enhances our understanding of the biology and life history of sDPS green sturgeon, including reproductive characteristics. North American green sturgeon are thought to reach sexual maturity at about 15 years of age (Van Eenennaam et al. 2006)—a total length of 150 to 155 cm for sDPS individuals. They can live to be 70 years old. Unlike salmon, they can spawn several times during their long lives, returning to their natal rivers every 2 to 6 years (Brown 2007, Poytress et al. 2013). They are long lived and late maturing, and spend substantial portions of their lives in marine and estuarine waters (NMFS 2010). Mora et al. (2018) estimated that there were 1,246 to 2,966 sDPS green sturgeon in the reproductive portion of the population during 2010 to 2015.

Adult southern DPS green sturgeon enter the San Francisco Bay between mid-February and early May before rapidly migrating up the Sacramento River to spawn. In fall, these post-spawn adults move back down the river and re-enter the ocean. After hatching, larvae and juveniles rear in their natal river or estuary before migrating to the ocean. As subadults and adults, sDPS green sturgeon migrate seasonally along the West Coast, congregating in bays and estuaries in Washington, Oregon, and California during the summer and fall months. During the winter and spring months, they congregate off of northern Vancouver Island, B.C., Canada. Huff et al. (2012) modeled the seasonal distribution of subadult and adult green sturgeon in coastal waters and identified waters shallower than 200 m (656 feet) along the Oregon and Washington Coasts as a high use area. This includes the waters of the Columbia River plume.[450] The modeled distribution was confirmed by the distribution of green sturgeon as bycatch in the limited entry trawl and California halibut fisheries (Huff et al. 2012).

Green sturgeon likely inhabit estuarine waters to feed and optimize growth (Moser and Lindley 2007), and these habitats appear to be important to subadult and adult green sturgeon. Individual green sturgeon exhibit diel movements, using deeper water during the day and moving to shallower water during the night to feed. The movements of green sturgeon are likely influenced by feeding behavior, tidal stage, and possibly light conditions (NMFS 2010). Green sturgeon tagged in Grays Harbor, Willapa Bay, and the lower Columbia River made use of all three systems, indicating frequent travel between and use of different estuarine areas (Lindley et al. 2011). Little is known about green sturgeon diet in estuaries or in the coastal ocean. Stomach sampling is challenging, and most studies have depended on samples collected from specimens at the dock or processing plants where stomachs are partially or completely empty. The best

[450] The Columbia River plume is defined as those waters contiguous to the mouth of the Columbia River having salinity less than 32.10 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005).

results are samples collected on the boat immediately after landing. Green sturgeon in Willapa Bay were found to feed primarily on benthic prey (e.g., Dungeness crab, crangonid shrimp, and thalassinid shrimp) and fish (Dumbauld et al. 2008). A very limited sample of green sturgeon stomachs in the Columbia River found mostly crangonid shrimp and some thalassinid shrimp (Dumbauld et al. 2008). The presence of these prey species suggests the sampled green sturgeon fed in the saline and brackish water reaches lower in the Columbia River estuary (downstream of approximately Columbia River mile 30) (NMFS 2010, 2015d).

2.16.2.1 Proposed Action and Action Area

The proposed action is described in Section 1.3. The distribution of the sDPS of green sturgeon overlaps with the action area in the lower Columbia River below Bonneville Dam and in the plume.

2.16.2.1.1 Action Agencies’ Effects Determinations

The Action Agencies determined that the proposed action is not likely to adversely affect the southern DPS of green sturgeon or their designated critical habitat.

2.16.2.1.2 Effects of the Proposed Action

The likely effects of the proposed action are:

- Injury or mortality of green sturgeon during boat-based electrofishing as a monitoring activity for the NPMP in sampling areas below Bonneville Dam. No green sturgeon of either DPS have been encountered in the monitoring program since it began in 1990. Thus, this pathway of effect is discountable.

CRS-related changes in flow, sediment transport, and other physical characteristics of the Columbia River estuary or plume that could negatively affect the species’ biological requirements in the action area.

In order to evaluate the likelihood of a negative effect through the latter pathway, we reviewed the available information on habitat use in the action area. Schreier et al. (2016) describe preliminary evidence of green sturgeon spawning in the Columbia River based on the collection of an age-0 individual near Rooster Rock (RM 130). However, genetic analyses assigned this individual to the unlisted northern DPS rather than the listed southern DPS, which is known to spawn only in the Sacramento River basin. Thus, the best available information indicates that the action area is used only for feeding by subadult and adult southern DPS green sturgeon.

Hansel et al. (2017) describe the areas in the lower Columbia River that were occupied by green sturgeon (they were not able to discern whether the fish were from the northern or the listed southern DPS) during 2010 and 2011 based on acoustic-tag detections between the mouth and RM 23.5. The purpose of the study was to identify habitat use, arrival, and departure timing, and the extent of upstream migration, to help design dredging operations to minimize harm to green sturgeon. A total of nine green sturgeon were detected in 2010, and 10 in 2011. These fish entered the Columbia River during May through October in both years, with the highest numbers present in August and September. Only one green sturgeon was detected at the uppermost receiver station (RM 23.5) and, overall, the number of fish detected decreased rapidly with distance from the estuary mouth. The residence times of fish that were only detected in the lower 3 miles of the river were less than 24 hours; fish detected farther upriver had a median residence time greater than 10 days. Green sturgeon were widely dispersed among channel and non-channel habitats in 2010 and more concentrated near the estuary mouth in 2011. Sensor tag data indicated that green sturgeon used a mix of habitats—the deep water south and north channel habitats (bottom depths ≥10 m), sandy shoals, shorelines, and bays (bottom depths <10 m).

Sensors also showed that water temperatures in areas used by these fish ranged from 48.4 to 71.6°F (late May through mid-October) (Hansel et al. 2017). Little is known about the thermal requirements of adult green sturgeon, but when sub-adults were manually tracked in the San Francisco Bay estuary, they occupied water with temperatures ranging from 58.1 to 69.4°F (Kelly et al. 2007). Adult green sturgeon have been tracked along the coast of Oregon and in Willapa Bay at temperatures ranging from 49.1 to 71.4°F (Moser and Lindley 2007, Huff et al. 2011). Thus, water temperatures in areas used in the lower Columbia River appear similar to those used in other parts of the species’ range.

Climate change has the potential to impact southern DPS green sturgeon in the future, but it is unclear how changing oceanic, nearshore and river conditions will affect the Southern DPS overall. In freshwater environments (e.g., Sacramento River system), water flow and temperature are important factors influencing green sturgeon spawning and recruitment success (NMFS 2015d). Changing conditions in the plume could also impact southern DPS green sturgeon since subadults and adults use ocean habitats for migration and potentially for feeding. Based on their use of coastal bay and estuarine habitats, subadults and adults can occupy habitats with a wide range of temperature, salinity, and dissolved oxygen levels, so predicting the impact of climate change in these environments is difficult (Kelly et al. 2007, Moser and Lindley 2007). Effects of the CRS on temperatures in the reach below RM 46 are greatly diminished because that area is also affected by tidal exchange with the ocean.

In summary, there is no evidence that changes in the spring hydrograph or sediment delivery to the estuary and plume, both effects of implementing the proposed action, are likely to interact with threats to the survival and recovery of this species. Thus, negative effects of the proposed action on the southern DPS of green sturgeon are highly unlikely to occur (discountable).

2.16.2.1.3 Critical Habitat

Designated critical habitat for southern DPS green sturgeon includes the lower Columbia River estuary from the river mouth to RM 74 (74 FR 52300, October 9, 2009) that support aggregations of southern DPS green sturgeon during summer. The PBFs essential for species conservation are:

- Food resources, including benthic invertebrates (crangonid and callianassid shrimp, Dungeness crab, mollusks, amphipods) and small fish such as sand lances (Ammodytes spp.) and anchovies (Engraulidae) (Moyle 2002, Dumbauld et al. 2008).
- Suitable water quality (e.g., temperature, salinity, oxygen levels necessary for normal behavior, growth, and viability).
- Migratory corridors necessary for safe and timely passage.
- Diversity of depths necessary for shelter, foraging, and migration.
- Sediment quality necessary for normal behavior, growth, and viability.

The effects of the proposed action will overlap with designated critical habitat for green sturgeon in the lower Columbia River below RM 74 (an estuarine area) and the plume (a coastal marine area). The designated critical habitat in the lower Columbia River estuary contains habitats that support aggregations of subadult and adult green sturgeon, including those from both the unlisted northern DPS and the listed southern DPS.

Potential effects of the proposed action on the PBFs of critical habitat include the following:

- **Food resources.** The PBF includes abundant prey items within estuarine habitats. Prey species for green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fishes, including crangonid shrimp, burrowing thalassinidean shrimp (particularly the burrowing ghost shrimp), amphipods, isopods, bivalves, annelid worms, crabs, sand lances, and anchovies (Dumbauld et al. 2008, NMFS 2009b). The availability of invertebrate and fish prey favored by green sturgeon in other estuaries appears to be high in the lower Columbia River, and there is no information to indicate that flow or sediment changes due to the CRS decrease the availability of these species in any measurable way. Thus, the effects of the proposed action on food resources is insignificant.
- **Water quality.** The PBFs of critical habitat in estuarine areas include water quality, comprising temperature, salinity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages (NMFS 2009b). Water temperature is affected by the existence and operation of the CRS hydroelectric dams and storage reservoirs. However, effects of the CRS on temperatures in the reach below RM 46 are greatly diminished because that area is also affected by tidal exchange with the ocean. Therefore, any negative effects of the CRS on the functioning of this aspect of the water quality PBF are likely to be insignificant. Green sturgeon can tolerate a wide range of salinities, spawning in freshwater but undertaking long range marine migrations when they leave the San Francisco Bay estuary; thus, the CRS is unlikely to have a negative effect on this PBF. Suitable water quality requires low levels of contaminants (e.g., pesticides, PAHs, heavy metals) that otherwise may disrupt growth and survival of subadult and adult life stages (NMFS 2009b). Implementation of the proposed action is not likely to concentrate or mobilize these contaminants or otherwise

affect this aspect of the water quality PBF; thus, we consider the effect of this pathway to be insignificant.

- **Migratory Corridor.** Migratory pathways allow safe and timely passage in the estuary and in coastal marine areas. There is no evidence that the proposed action will have a negative effect on this PBF.
- **Water Depth.** Subadult and adult green sturgeon require a diversity of depths in estuarine areas for shelter, foraging, and migration. There is no evidence that implementation of the proposed action will negatively affect access to either bottom or near-surface waters that might be used by subadults or adults; thus, the effects are discountable.
- **Sediment Quality.** Sediment quality necessary for normal behavior, growth, and viability of all green sturgeon life stages includes sediments free of elevated levels of contaminants, such as PAHs and pesticides (NMFS 2009b). There is no likely pathway for implementation of the proposed action to affect sediment quality in the estuary, and the effects to sediment quality are discountable.

As described above, we have reviewed the available scientific and technical information on critical habitat used by green sturgeon in the lower Columbia River and plume, and we consider the likelihood of negative effects on the PBFs of these habitats to be insignificant or discountable. In addition, the Action Agencies will continue the estuary habitat improvement work under the proposed action. This habitat work will continue to improve ecosystem functions in the estuary, and may contribute to the future prey base for feeding subadult and adult Southern DPS green sturgeon.

2.16.2.1.4 Conclusion

Based on the above analysis, NMFS concurs with the Action Agencies that the proposed action is not likely to adversely affect southern DPS green sturgeon and its designated critical habitat because all the effects of the proposed action are either discountable or insignificant.

2.17 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. “Harm” is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this Incidental Take Statement.

The measures described in this section are nondiscretionary and must be undertaken by the Action Agencies: Corps, BPA, and Reclamation. The Action Agencies have a continuing duty to regulate the activities covered by this Incidental Take Statement. If the Action Agencies fail to assume and implement the terms and conditions of this Incidental Take Statement, the protective coverage of Section 7(o)(2) may lapse. To monitor the effect of incidental take, the Action Agencies must report the progress of the action and its effect on each listed species to NMFS, as specified in this Incidental Take Statement (50 C.F.R § 402.14(i)(3)).

2.17.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take will occur as a result of the continued operation of the CRS and the implementation of the proposed action. Categories of incidental take are: CRS operations, habitat improvement, hatchery, predator management actions, and RME activities. The following sections specify the amount or extent of take that NMFS anticipates will occur as a result of these actions.

2.17.1.1 Amount of Take from CRS Operations, Maintenance, and Hydropower Actions

NMFS has estimated the expected injury, harm and/or mortality attributable to proposed operation of the CRS (including the mainstem flow effects of Hungry Horse, Columbia Basin Project [Grand Coulee], Chief Joseph Dam, The Dalles, Yakima, Deschutes, and Umatilla irrigation projects) in Sections 2.5 to 2.15. In this section, NMFS summarizes the expected incidental take of ESA-listed salmon and steelhead species and eulachon, resulting from the continued operation of the CRS and implementation of the proposed action, including the development of surrogates for the amount or extent of take anticipated where it is not practical to numerically estimate in terms of individuals of the listed species.

2.17.1.1.1 Take of Adult Salmon and Steelhead

<u>Adult Migrants</u>

NMFS expects that the current estimated annual averages (and ranges) of mortalities for upstream migrating adults measured within the appropriate mainstem reaches will continue under the proposed action (Table 2.17-1). These estimates remove any reported harvest and account for estimated adult stray rates that would occur in an unmanaged migration corridor of similar size. The estimated adult mortality rates include all other sources that are likely to take place within the identified reaches: mortality resulting from the existence and operation of the CRS, unreported or delayed mortality caused by fisheries and marine mammal predator attacks, and natural mortality (i.e., that would have occurred during upstream migration without human influence).

These estimates represent higher levels of mortality than are due to the operation and maintenance of the CRS alone. As it is not practical to determine the precise amount of adult migrant mortality occurring only as a result of the proposed operation and maintenance of the CRS, we are using averages of the annual mortality estimates (the complement of survival estimates) as a surrogate for the amount or extent of take anticipated. Doing so provides a clear standard for determining when take has been exceeded, and considering the relatively precise estimated mortality rates, changes in the amount or extent of take caused by CRS operations would be evident in the annual mortality estimates.

There is evidence (PIT tag detections in adult fishways) that small numbers of adult UWR Chinook salmon and UWR steelhead occasionally pass upstream of Bonneville Dam. Some losses are likely to occur as a result of these fish moving back downstream through the project to reach their natal streams. Otherwise, all take experienced by UWR Chinook salmon and UWR steelhead is in the form of harm or reduced fitness from the biophysical changes in the lower Columbia River as these fish migrate up the Columbia River to its confluence with the Willamette River.

Mainstem Spawning

Quantitative estimates of take are not possible for the mainstem spawning and incubation life stages of SR fall Chinook, LCR Chinook, and CR chum salmon. Reliable estimates of the numbers of fry or juveniles reaching the first project (e.g., SR fall Chinook at Lower Granite Dam, LCR Chinook at Bonneville Dam, etc.) are not available, or are extremely complicated because of multiple life history strategies. Reliable estimates of CR chum emerging from mainstem redds below Bonneville Dam are similarly not available. October through April water management operations are designed to provide relatively stable, beneficial conditions for adult spawners and their incubating eggs, and emerging and migrating fry, while considering the needs of juvenile and adult migrants from other ESA-listed species. Therefore, as a surrogate, the extent of take indicator for mainstem spawners and their incubating eggs, and emerging and migrating fry, will be the operation of the CRS dams in accordance with the water management operations and adaptive management processes specified (following concurrence by NMFS) in the annual Water Management Plan (2020 and thereafter).

Table 2.17-1. Averages (and ranges) of annual adult salmonid mortality estimates (wild and hatchery origin fish combined) based on PIT tag detections at Bonneville Dam and at the uppermost Federal dam likely to be passed by fish from each ESU/DPS. Data are based on adult return years 2010-19. Shaded cells denote mortality estimates for the ESUs/DPS for which species-specific data were not available and data from another, similar, species was used as a surrogate. Species which are not transported are denoted as not applicable (NA).

ESU	Estimated Mortality of Adults if Migrated Inriver as Juveniles[1]		Estimated Mortality of Adults if Transported as Juveniles[1]		Reach	Notes
	Average	Range	Average	Range		
SR spr/sum Chinook salmon	16.8%	6.5–23.4%	20.5%	11.8–27.0%	BON to LGR (7 dams)	
SRB steelhead	12.4 %	5.9–18.8%	22.2%	13.8–25.5%	BON to LGR (7 dams)	
SR sockeye salmon[2]	34.9%	17.2–53.6%	NA	NA	BON to LGR (7 dams)	2012-2014, 2016-2017 average. Once within the next 15 years, high temperatures could result in high (96%) losses of adult sockeye salmon.
SR fall Chinook salmon	11.2%	0–22.4%	17.5%	6.2–32.3%	BON to LGR (7 dams)	2010-2018 average
UCR spring Chinook salmon	6.1%	0–16.2%	NA	NA	BON to MCN (3 dams)	
UCR steelhead	7.8%	3.2–12.4%	NA	NA	BON to MCN (3 dams)	
MCR steelhead[3] **1 dam** **2 dams** **3 dams**	 1.3% 2.6% 3.8%	 0–4.0% 0–7.8% 0–11.5%	NA	NA	BON to TDA, JDA, MCN, or tributaries above MCN	Populations enter the Columbia in different mainstem reservoirs
CR chum salmon[5]	2.5%	0–7.6%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool
LCR Chinook salmon – spring runs[4]	3.9%	0–6.7%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool
LCR Chinook salmon – fall runs[5]	2.5%	0–7.6%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool
LCR steelhead[6]	4.1%	0.4–3.4%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool
LCR coho salmon[5]	2.5%	0–7.6%	NA	NA	BON to tributaries	Applies only to populations that

ESU	Estimated Mortality of Adults if Migrated Inriver as Juveniles[1]		Estimated Mortality of Adults if Transported as Juveniles[1]		Reach	Notes
	Average	Range	Average	Range		
					entering BON pool	migrate to natal streams within BON pool
UWR Chinook salmon	10 individuals	NA	NA	NA		A few adults from this ESU migrate upstream of BON in some years and some of these fish may die migrating downstream past the project.
UWR steelhead	10 individuals	NA	NA	NA		

[1] Generally calculated as 1 – Adjusted Survival Estimates (estimates of harvest and "natural" stray rates are removed) for the pertinent reach.

[2] There are no available estimates of adult passage survival for transported sockeye salmon, however, it is reasonable that transported SR sockeye might exhibit mortalities similar to those differentials observed for SR spring/summer Chinook (6.7 percent) and SRB steelhead (10.3 percent).

[3] Uses Walla Walla River and Yakima River MCR steelhead to estimate survival for these and stocks that pass through fewer than 4 dams (average per-project survival ^ Nth power, where N corresponds to the number of dams upstream of Bonneville passed during the migration) from Bonneville Dam to the natal tributaries of these fish that enter within a lower Columbia River reservoir.

[4] Uses SR spring-run Chinook salmon estimates as a surrogate estimate (i.e., the average per project survival estimate is used as a conservative estimate of survival from Bonneville Dam to the natal tributaries of these fish entering within the Bonneville reservoir).

[5] Uses SR fall-run Chinook salmon as a surrogate estimate (i.e., the average per project survival estimate is used as a conservative estimate of survival from Bonneville Dam to the natal tributaries of these fish entering within the Bonneville reservoir).

[6] Uses SRB steelhead from Bonneville to McNary dam as a surrogate estimate (i.e., the average per project survival estimate is used as a conservative estimate of survival from Bonneville Dam to the natal tributaries of these fish entering within the Bonneville reservoir).

Sockeye Transport

Consistent with the recommendations presented in NMFS' 2015 Adult Sockeye Salmon Passage Report (NMFS 2016a), trapping and transporting adult sockeye salmon from Lower Granite Dam when elevated water temperatures (greater than 70°F) exist in the Columbia, Snake, or Salmon Rivers will reduce adult sockeye mortalities and increase the number of spawning fish. Per event, up to 50 percent of the fish estimated to pass Lower Granite Dam under these conditions may be removed and transported with an associated mortality rate of up to 10 percent of the transported fish.

Adult listed Chinook salmon and steelhead are also likely to be handled incidentally in the process of capturing sockeye for transport and their incidental take will exceed that of sockeye salmon. Up to 7 percent of SR summer Chinook salmon and 1 percent of SR steelhead pass Lower Granite Dam when adult sockeye salmon are passing. However, effects on these fish (handling and delayed passage) are expected to be minimal. Thus the amount of take anticipated in the form of mortalities for these non-targeted species, is 20 adult SR summer Chinook salmon and ten adult SR steelhead, per event, as a result of adult sockeye transport. Mortalities for these non-targeted species are generally proportional to the number of fish that experience handling and delayed passage; therefore, they are also a useful indicator of the amount of injury and/or harm from trapping operations in that respect.

2.17.1.1.2 Take of Juvenile Salmon & Steelhead

NMFS expects mortality of inriver migrating juveniles to decrease slightly, remain at recent levels, or increase slightly due to implementation of the flexible spill operation, based on COMPASS model results for the proposed action's effects on SR spring/summer Chinook salmon, SRB steelhead, UCR spring Chinook salmon, UCR steelhead, and MCR steelhead, relative to the No Action Alternative (USACE et al. 2020). For other species, which cannot be modelled using COMPASS, NMFS uses recent estimates of direct mortality (or estimates from similar species as surrogates, if not available) for specific river reaches under recent operations. These estimates of reach-specific mortality in Table 2.17-2 capture all sources of mortality and represent NMFS' estimates of the mortalities (1 - survival) that are likely to be observed under the proposed action. They include quantifiable direct mortality from the existence and operation of the CRS, unquantifiable and indirect mortality from other potential sources that occur upstream of Bonneville Dam (e.g., predation, hatchery-related effects, disease, exposure to toxic chemicals, etc.), and unquantifiable "natural" levels of mortality (i.e., mortality in the migration corridor that would have occurred without human influence).

The estimates in Table 2.17-2 represent higher levels of mortality than are due to the operation and maintenance of the CRS alone. As it is not practical to determine the precise amount of juvenile migrant mortality occurring only as a result of the proposed operation and maintenance of the CRS, we are using the averages (and ranges) of annual mortality estimates as surrogates for the amount or extent of take anticipated. For ESU/DPSs for which species-specific data were not available, we used, as a surrogate, estimates from another similar species. Doing so provides a clear standard for determining when take has been exceeded. Although there are more factors contributing to juvenile mortality than for adults, and mortality estimates are higher overall for juveniles than for adults, the proposed action includes measures intended to reduce and/or maintain the effects of many of these factors, such as measures to limit the effects of key predators. Based on our review in the opinion, we anticipate that those measures will be successful in maintaining or reducing associated mortality. Accordingly, the average mortality rates and ranges of annual estimates provide a useful indicator of the overall amount of take anticipated for migrating juveniles resulting from the proposed action. The average mortality rates provide a benchmark to assess whether the effects of the proposed action, in terms of take of juveniles, becomes greater than expected.

Estimates of the average proportion of Snake River salmon and steelhead approaching Lower Granite Dam that are likely to be transported, the mortality rates associated with transportation (as a percentage of juveniles approaching Lower Granite Dam), and the mortality rates of inriver migrating juveniles under the proposed operation are presented in Table 2.17-2. These estimates are based on COMPASS modeling and recent transport estimates. Many years of research have consistently demonstrated that direct mortalities of transported juvenile salmon and steelhead from the Snake River basin are 2 percent or less (from collector projects to release locations below Bonneville Dam), but it is impractical to make these estimates every year. As a surrogate, the take indicator for transported juvenile salmon and steelhead from the Snake River collector projects will be the operation of juvenile bypass system, transportation facilities, and fish transport barges as specified in annual Fish Passage Plans for 2020 and subsequent years.

Reliable estimates of the numbers of fry or juvenile SR fall Chinook salmon reaching the first project (e.g., Lower Granite Dam) are not available; multiple life history strategies make it challenging to generate reasonable estimates when fish pass the dam at different times in their life cycle. Flow operations are intended to provide beneficial conditions for emerging and migrating fry and smolts. Implementing beneficial flow operations—using regional forums for adaptive management—is the most useful indicator for whether or not conditions to minimize take are occurring for those SR fall Chinook salmon that are not migrating as typical subyearling smolts (i.e., fry and later migrating juveniles that are likely to rear in the reservoirs and migrate the following year). Because it is not possible to fully quantify take associated with the migration of juvenile fall Chinook salmon in the CRS system, the take indicator for juvenile SR fall Chinook salmon is flow and dam operations implemented as described in the proposed action. Take of juvenile SR fall Chinook salmon is assumed to be exceeded if flow and dam operations are inconsistent with the annual Water Management and Fish Operations Plans (beginning in 2020) such that the effects exceed those described in the Effects Analysis, above. Survival estimates from Lower Granite to Bonneville Dam for subyearling hatchery fish that migrate soon after release during the spring period are available (Table 2.17-2). Although these survival estimates apply to only one of several life history strategies, they do provide a surrogate measure for many hatchery-produced fish included in this ESU as well as naturally produced subyearling SR fall Chinook salmon from the upper and lower Hells Canyon major spawning aggregates.

Table 2.17-2. Percent transported and mortality rates estimated for juvenile salmon and steelhead that are transported or that migrate inriver to Bonneville Dam tailrace. SR spring/summer Chinook salmon, SRB steelhead, UCR spring-run Chinook salmon, UCR steelhead, and MCR steelhead use estimates for the proposed action from the COMPASS model.[1] COMPASS estimates are not available for the other ESU/DPSs. SR sockeye salmon and SR fall Chinook salmon use data from recent juvenile migration years for percent mortality of inriver migrants. Recent transport estimates are used for estimating the percent of SR sockeye salmon expected to be transported. COMPASS model estimates for SR spring/summer Chinook are used as a surrogate for estimating the percent of SR fall Chinook salmon expected to be transported. CR chum salmon, LCR Chinook salmon, LCR steelhead, and LCR coho salmon use COMPASS estimates for surrogate ESU/DPSs (see notes column). ESU/DPSs that are not transported are denoted as not applicable (NA).

ESU/DPS	Percent of Juveniles Transported,[2] Average (Range)	Estimated Mortality of Juveniles, Transported Component,[3] Average (Range)	Estimated Mortality of Juveniles Migrating Inriver Component,[4] Average (Range)	Notes
SR spr/sum Chinook salmon	25.4% (4.1–56.5%)	0.51% (0.08–1.13%)	49.2% (36.0–75.8%)	
SRB steelhead	26.4% (12.1–56.1%)	0.53% (0.24–1.12%)	57.4% (44.5-78.4%)	
SR sockeye salmon	43% (22.0–56.9%)	0.86% (0.44–1.14%)	44.3% (28.7–56.6%)	Uses annual estimates of percent transported (2013-2019) and inriver survival (2010-2019, excluding 2011 and 2015-2017).[5]
SR fall Chinook salmon	25.4% (4.1–56.5%)	0.51% (0.08–1.13%)	50.0% (23.9-89.8)	Uses annual estimates of inriver survival for SR fall Chinook (2010-2019),[6] and COMPASS results for SR spr/sum Chinook salmon as a surrogate for percent transported.
UCR spring-run Chinook salmon	NA	NA	29.2% (23.6-41.7%)	McNary to Bonneville Dam
UCR steelhead	NA	NA	33.8% (28.1-45.5%)	McNary to Bonneville Dam
MCR steelhead[7]	NA	N/A		
Passing MCN			41.7% (32.3–59.7%)	
Passing JDA			33.3 (25.4-48.8%)	
Passing TDA			23.7% (17.7%-36.3%)	
Passing BON			12.6% (9.3-20.0%)	
CR chum salmon	N/A	N/A	11.2% (7.1-24.2%)	Uses SR spr/sum Chinook salmon est. of Bonneville Dam survival as a surrogate
LCR Chinook salmon	N/A	N/A	11.2% (7.1-24.2%)	Uses SR spr/sum Chinook salmon est. of

ESU/DPS	Percent of Juveniles Transported,[2] Average (Range)	Estimated Mortality of Juveniles, Transported Component,[3] Average (Range)	Estimated Mortality of Juveniles Migrating Inriver Component,[4] Average (Range)	Notes
				Bonneville Dam survival as a surrogate
LCR steelhead	NA	N/A	12.6% (9.3-20.0%)	Uses SRB steelhead est. of Bonneville Dam survival as a surrogate
LCR coho salmon	N/A	N/A	11.2% (7.1-24.2%)	Uses SR spr/sum Chinook salmon est. of Bonneville Dam survival as a surrogate

[1] The COMPASS model has been calibrated using recent empirically derived survival estimates for the passage years 2013-2018. The reported estimates therefore capture all sources of mortality exhibited within the migration corridor including those resulting from the existence and operation of the CRS, unquantifiable mortalities from other potential sources (e.g., indirect effects of the CRS that occur upstream of Bonneville Dam, mortalities resulting from avian or piscivorous predators, mortalities associated with the condition of hatchery fish or exposure to chemicals or pathogens, etc.) and unquantifiable levels of "natural" mortality (i.e., levels of mortality in the migratory corridor that would have occurred without human influence).

[2] The estimated proportion of fish arriving at Lower Granite Dam that will be collected and transported at one of the three collector projects.

[3] Based on the information available, NMFS uses 2 percent as a reasonable estimate of direct mortality for transported juvenile salmonids.

[4] Expected mortalities of inriver migrating juvenile salmon and steelhead (1 - Inriver Survival) based on COMPASS modeling or other sources described in notes.

[5] SR sockeye salmon mortality estimates are based on mean annual survival data from 2010, 2012-2014, and 2018-2019 (Widener et al. 2020). Migration year 2011 estimates could not be made due to too few PIT tag detections at or downstream of Bonneville Dam, and 2015-2017 had unusually low survival of smolts released from the Springfield Hatchery. Annual percent transported (2013-2019) is reported in Smith (2020).

[6] SR fall Chinook salmon annual juvenile survival (2010-2019) is reported in Smith (2020).

[7] Populations of MCR steelhead enter the Columbia River from upstream of McNary Dam (Yakima and Walla Walla), John Day Dam (Umatilla and John Day), The Dalles Dam (Deschutes), and Bonneville Dam (tributaries to Bonneville Reservoir).

2.17.1.1.3 Take of Adult Eulachon

Direct effects of the proposed action on eulachon can be estimated by looking at the available eulachon data from the downstream migrant trap at Bonneville Dam (a predecessor to the juvenile bypass system) representing a substantial fraction of the total numbers of eulachon migrating upstream of the dam. Based on a single incident in 1988, up to 95,500 adults were harmed or killed at Bonneville Dam, having passed downstream through the trap that year (NMFS 2008a). Even though no eulachon are observed at Bonneville Dam in most years there is the potential that a large return of eulachon passing upstream of Bonneville Dam could occur within the expected duration of the proposed action. Therefore, we estimate that incidental take (the number of fish passing downstream through the juvenile bypass system) will be less than 95,500 adult eulachon annually and in no more than 1 out of every 5 years will there be a large return of eulachon passing upstream of Bonneville Dam.

In addition to take associated with the operation of Bonneville Dam, permitted incidental take of adult eulachon for CRS research activities will include the capture and handling of up to 21,000 adults in no more than 1 out of every 5 years, with the potential for up to 210 fish (1 percent) to be killed in these years. It should be noted that in recent years (2016 to 2019) zero eulachon have been encountered during CRS research activities.

2.17.1.2 Amount of Incidental Take from Habitat Improvement Actions

Completion of the proposed habitat improvement activities will take place beside and within streams used for spawning and rearing and in estuarine areas used for rearing and migration by the listed ESUs/DPSs. Due to the short-term adverse effects of implementing restoration activities, incidental take is reasonably certain to occur.

Take of listed salmonids resulting from habitat projects developed to implement the proposed action and authorized, funded, or carried out by BPA, that are consistent in type, design, and methods of implementation to those covered by the ESA Section 7 Formal Programmatic Biological and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Bonneville Power Administration's Habitat Improvement Program 4 (HIP 4) (NMFS 2020), is addressed by the incidental take statement for that biological opinion. Take resulting from projects that fall outside the explicit criteria in the HIP 4 Biological Opinion will require separate and subsequent consultation. NMFS authorizes no additional take of ESA-listed species in this biological opinion (beyond that previously authorized by the HIP 4 Biological Opinion) for the proposed habitat restoration activities.

2.17.1.3 Amount of Incidental Take from Hatchery Actions

Incidental take from hatchery actions funded as part of, or caused by, the proposed action is assessed in separate biological opinions for each hatchery operation plan and is included in the HGMP for the program. Thus, no additional take of ESA-listed salmon and steelhead is authorized for hatchery actions in this incidental take statement.

2.17.1.4 Amount of Incidental Take from Predator Control Measures

No take (lethal or non-lethal) of salmonids is expected to result from the avian predator control measures.

Some unquantifiable, but very small, amount of take of adult and juvenile SR spring/summer Chinook, SR fall Chinook, UCR spring Chinook, LCR Chinook salmon, SR steelhead, UCR steelhead, MCR steelhead, LCR steelhead, LCR coho, and CR chum is likely to occur as a result of marine mammal deterrent measures (cracker shells and "bombs"[451]) occurring downstream of Bonneville Dam, and, if necessary, downstream of The Dalles Dam. Some individuals are likely to be harassed and a few (on the scale of individual fish) could be killed as a result implementing measures to deter marine mammal predation. In addition, some individual juveniles from the

[451] "Bombs" are small explosive charges that are detonated underwater.

ESUs/DPSs with spring migrating juveniles could be harassed or even killed as a result of implementing measures to deter marine mammal predation. It is not possible to quantify the amount of take per species because the effects cannot be observed (fish are underwater). Thus, we need to use a surrogate for the extent of take. The appropriate surrogate is implementation of the planned operation within the specific time period; there is a direct link between the intensity of the deterrent measures in the plan and the number of fish that are harmed or killed. Incidental take will not be exceeded if these deterrence operations take place within the August 1st to May 31st time period each year.

Listed salmonids will also be taken during implementation of the Sport Reward Fishery and Dam Angling portions of the NPMP. Based on numbers of fish handled and/or killed during 2014-18, the Sport Reward Fishery will handle up to 100 each of adult Chinook salmon (including jacks) and steelhead, and up to ten each of adult coho, chum and sockeye salmon from all ESUs/DPSs combined each year. The Sport Reward Fishery will also handle and/or kill up to 200 juvenile Chinook salmon, 600 juvenile steelhead, 100 juvenile coho, and up to ten each of juvenile chum and sockeye salmon. These juvenile fish cannot be identified to the ESU or DPS level, so the extent of take indicator for the Sport Reward Fishery is 720 juvenile salmonids per year. The Dam Angling Program will handle and/or kill up to ten each of adult Chinook salmon and steelhead, up to five adult sockeye salmon, and no adult coho or chum salmon annually. Dam anglers will also handle and/or kill up to 20 juvenile Chinook, 20 juvenile steelhead, 10 juvenile sockeye, and one juvenile coho or chum salmon annually.

2.17.1.5 Amount or Extent of Incidental Take from RME Actions

This section identifies the amount or extent of incidental take anticipated under this opinion for RME actions.

The Action Agencies, or their contractors, propose to implement the following RME actions:

1. Monitor the status of selected fish populations related to CRS actions,
2. Monitor performance and adaptive management related to Hydropower Operations,
3. Monitor performance and adaptive management related to Tributary Habitat Improvement Actions,
4. Monitor performance and adaptive management related to Estuary Habitat Improvement Actions,
5. Monitor performance and adaptive management related to Predation Management Actions, and
6. Track Project compliance, implementation and effectiveness through monitoring programs and projects.

Many of these RME actions will result in short-term adverse impacts on listed salmonids. The primary adverse effects the proposed monitoring activities will have on listed species will be in the form of incidental take caused by observing, capturing, and handling fish, which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering.

Tables 2.17-3 through 2.17-5 specify, by type of RME activity, the amount of take of adult and juvenile salmon and steelhead and eulachon anticipated. These take limits are based on requested and reported take for RME activities over the last 4 years, as well as recent, 5-year average run sizes. The new limits, especially for certain ESUs/DPSs, are often significantly lower than take limits approved under the 2008 and 2019 biological opinions. If average run sizes become more abundant in the future (i.e., substantially higher than the recent, 5-year average run sizes), the take associated would increase beyond the numeric estimates, but should not exceed the proportion of the run estimates. Sublethal take includes observation, capture, handling, measurement, collection of samples, tagging, and other activities which have some negative effect on the fish without causing death. Incidental mortalities are unintentional fish deaths which occur during the normal course of the study.

NMFS has determined that the NPMP field crew observations of juvenile and adult salmonids shocked during electrofishing are the best method for estimating take associated with the sport reward fishery tagging and biological evaluation efforts (via boat electrofishing).[452] The average annual number of salmonids observed during NPMP electrofishing activities from the lower Columbia River estuary to the Lower Granite Dam reservoir from 2014 to 2019 is ~90,000 juvenile and ~1,600 adult salmonids, and the average take from these activities should not exceed these values.

[452] Under past CRS biological opinions, incidental take for NPMP electrofishing efforts was authorized using a surrogate measure ("up to 550 hours per year at a rate of 15 minutes per km on each side of the river between RM 47 and Priest Rapids Dam in the Columbia River and up to RM 159 in the Snake River, and 15 min per 0.31-mile transect in the lower Columbia River").

Table 2.17-3. Average annual estimates of non-lethal take (i.e., handling, including injury) and incidental mortality associated with implementation of the Smolt Monitoring Program and the Comparative Survival Study as a percent of recent run size estimates (2014 to 2018 or 2015 to 2019). Incidental mortality is added to (not a subset of) non-lethal take.

	Smolt Monitoring Program and Comparative Survival Study									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Upper Columbia	UCR spring Chinook	Number	1	1	1	1	9,600	192	8,620	172
		% of run	0.01%	0.01%	0.03%	0.03%	0.91%	0.02%	1.72%	0.03%
	UCR steelhead	Number	1	1	1	1	11,500	23	7,000	140
		% of run	0.01%	0.01%	0.03%	0.03%	1.35%	0.00%	3.31%	0.07%
Snake River	SR fall Chinook	Number	1	1	1	1	145,600	2,877	52,325	613
		% of run	0.00%	0.00%	0.01%	0.01%	2.82%	0.06%	6.43%	0.08%
	SR sockeye	Number	1	1	1	1	8,460	170	1,855	30
		% of run	0.15%	0.15%	1.30%	1.30%	3.45%	0.07%	9.62%	0.16%
	SRB steelhead	Number	1	1	1	1	43,000	827	16,400	318
		% of run	0.00%	0.00%	0.01%	0.01%	1.06%	0.02%	2.01%	0.04%
	SR spr/sum Chinook	Number	1	1	1	1	83,400	1,596	40,000	1,000
		% of run	0.00%	0.00%	0.01%	0.01%	1.52%	0.03%	3.60%	0.09%

	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Smolt Monitoring Program and Comparative Survival Study										
Mid-Columbia	MCR steelhead	Number	1	1	1	1	10	1	12,000	240
		% of run	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%	2.89%	0.06%
Lower Columbia	LCR Chinook	Number	1	1	1	1	0	0	22,800	456
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.19%	0.00%
	LCR steelhead	Number	1	1	1	1	0	0	1,686	3
		% of run	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.48%	0.00%
	LCR coho	Number	1	1	1	1	0	0	2,000	40
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%	0.01%
	CR chum	Number	1	1	1	1	0	0	500	10
		% of run	0.18%	0.18%	0.01%	0.01%	0.00%	0.00%	0.01%	0.00%

Table 2.17-4. Average annual estimates of non-lethal take (i.e., handling, including injury) and incidental mortality associated with implementation of other RME activities [other than the Smolt Monitoring Program/Comparative Survival Study] as a percent of recent run size estimates (2014-18 or 2015-19). Incidental mortality is added to (not a subset of) non-lethal take.

	Other Monitoring & Research									
	ESU/DPS		**Adult**				**Juvenile**			
			Hatchery		**Wild**		**Hatchery**		**Wild**	
			Non-lethal Take	**Incidental Mortality**	**Non-lethal Take**	**Incidental Mortality**	**Non-lethal Take**	**Incidental Mortality**	**Non-lethal Take**	**Incidental Mortality**
Upper Columbia	UCR spring Chinook	Number	300	10	300	10	2,870	21	9,992	133
		% of run	1.76%	0.06%	8.28%	0.28%	0.27%	0.00%	2.00%	0.03%
	UCR steelhead	Number	300	10	300	10	5,500	214	9,000	70
		% of run	4.32%	0.14%	9.14%	0.30%	0.65%	0.03%	4.26%	0.03%
Snake River	SR fall Chinook	Number	4,800	50	2,000	20	225,150	2,223	85,675	987
		% of run	16.62%	0.17%	18.29%	0.18%	4.36%	0.04%	10.53%	0.12%
	SR sockeye	Number	139	2	12	1	11,540	130	1,145	5
		% of run	20.56%	0.30%	15.58%	1.30%	4.71%	0.05%	5.94%	0.03%
	SRB steelhead	Number	12,700	60	3,200	15	125,000	1,250	64,600	382
		% of run	19.93%	0.09%	20.64%	0.10%	3.08%	0.03%	7.94%	0.05%
	SR spr/sum Chinook	Number	7,700	77	2,200	22	78,293	681	71,000	500
		% of run	16.15%	0.16%	20.38%	0.20%	1.43%	0.01%	6.39%	0.05%

	ESU/DPS		Other Monitoring & Research							
			Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Mid-Columbia	MCR steelhead	Number	500	18	700	18	1,000	10	10,000	100
		% of run	2.74%	0.10%	3.81%	0.10%	0.20%	0.00%	2.41%	0.02%
Lower Columbia	LCR Chinook	Number	900	10	400	10	10,000	100	27,200	544
		% of run	0.53%	0.01%	1.64%	0.04%	0.03%	0.00%	0.23%	0.00%
	LCR steelhead	Number	100	10	200	10	5,000	50	1,814	32
		% of run	0.19%	0.02%	1.38%	0.07%	0.40%	0.00%	0.51%	0.01%
	LCR coho	Number	1,000	10	600	10	20,000	200	19,000	560
		% of run	0.38%	0.00%	1.91%	0.03%	0.26%	0.00%	2.87%	0.08%
	CR chum	Number	20	1	400	4	40,000	400	1,000,000	7,000
		% of run	3.57%	0.18%	2.13%	0.02%	5.23%	0.05%	14.47%	0.10%
Willamette	UWR Chinook	Number	200	10	200	10	5,000	50	1,000	50
		% of run	1.24%	0.06%	1.12%	0.06%	0.10%	0.00%	0.08%	0.00%
	UWR steelhead	Number	80	10	30	5	1,000	10	1,000	10
		% of run	0.94%	0.12%	0.93%	0.15%	0.58%	0.01%	0.71%	0.01%

<table>
<tr><th rowspan="4"></th><th colspan="10">Other Monitoring & Research</th></tr>
<tr><th rowspan="3">ESU/DPS</th><th></th><th colspan="4">Adult</th><th colspan="4">Juvenile</th></tr>
<tr><th></th><th colspan="2">Hatchery</th><th colspan="2">Wild</th><th colspan="2">Hatchery</th><th colspan="2">Wild</th></tr>
<tr><th></th><th>Non-lethal Take</th><th>Incidental Mortality</th><th>Non-lethal Take</th><th>Incidental Mortality</th><th>Non-lethal Take</th><th>Incidental Mortality</th><th>Non-lethal Take</th><th>Incidental Mortality</th></tr>
<tr><td rowspan="2">Other</td><td rowspan="2">Eulachon</td><td>Number</td><td colspan="2" rowspan="2">NA</td><td>21,000</td><td>210</td><td colspan="2" rowspan="2">NA</td><td colspan="2" rowspan="2">NA</td></tr>
<tr><td>% of run</td><td>0.04%</td><td>0.00%</td></tr>
</table>

Table 2.17-5. Average annual estimates of all non-lethal take (i.e., handling, including injury) and incidental mortality associated with implementation of the Smolt Monitoring Program/Comparative Survival Study, and other types of RME considered in this opinion as a percent of recent run size estimates (2014-18 or 2015-19). Incidental mortality is added to (not a subset of) non-lethal take.

	Grand Total									
	ESU/DPS		**Adult**				**Juvenile**			
			Hatchery		**Wild**		**Hatchery**		**Wild**	
			Non-lethal Take	**Incidental Mortality**	**Non-lethal Take**	**Incidental Mortality**	**Non-lethal Take**	**Incidental Mortality**	**Non-lethal Take**	**Incidental Mortality**
Upper Columbia	UCR spring Chinook	Number	301	11	301	11	12,470	213	18,612	305
		% of run	1.76%	0.06%	8.30%	0.30%	1.19%	0.02%	3.72%	0.06%
	UCR steelhead	Number	301	11	301	11	17,000	237	16,000	210
		% of run	4.34%	0.16%	9.17%	0.34%	2.00%	0.03%	7.57%	0.10%
Snake River	SR fall Chinook	Number	4,801	51	2,001	21	370,750	5,100	138,000	1,600
		% of run	16.63%	0.18%	18.30%	0.19%	7.18%	0.10%	16.96%	0.20%
	SR sockeye	Number	140	3	13	2	20,000	300	3,000	35
		% of run	20.71%	0.44%	16.88%	2.60%	8.16%	0.12%	15.55%	0.18%
	SRB steelhead	Number	12,701	61	3,201	16	168,000	2,077	81,000	700
		% of run	19.94%	0.10%	20.64%	0.10%	4.14%	0.05%	9.95%	0.09%
	SR spr/sum Chinook	Number	7,701	78	2,201	23	161,693	2,277	111,000	1,500
		% of run	16.15%	0.16%	20.39%	0.21%	2.96%	0.04%	10.00%	0.14%
Mid - Col	MCR steelhead	Number	501	19	701	19	1,010	11	22,000	340

	ESU/DPS		Grand Total							
			Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
		% of run	2.75%	0.10%	3.82%	0.10%	0.20%	0.00%	5.29%	0.08%
Lower Columbia	LCR Chinook	Number	901	11	401	11	10,000	100	50,000	1,000
		% of run	0.54%	0.01%	1.65%	0.05%	0.03%	0.00%	0.42%	0.01%
	LCR steelhead	Number	101	11	201	11	5,000	50	3,500	35
		% of run	0.19%	0.02%	1.38%	0.08%	0.40%	0.00%	0.99%	0.01%
	LCR coho	Number	1,001	11	601	11	20,000	200	21,000	600
		% of run	0.38%	0.00%	1.91%	0.03%	0.26%	0.00%	3.17%	0.09%
	CR chum	Number	21	2	401	5	40,000	400	1,000,500	7,010
		% of run	3.74%	0.36%	2.13%	0.03%	5.23%	0.05%	14.48%	0.10%
Willamette	UWR Chinook	Number	200	10	200	10	5,000	50	1,000	50
		% of run	1.24%	0.06%	1.12%	0.06%	0.10%	0.00%	0.08%	0.00%
	UWR steelhead	Number	80	10	30	5	1,000	10	1,000	10
		% of run	0.94%	0.12%	0.93%	0.15%	0.58%	0.01%	0.71%	0.01%
Other	Eulachon	Number	NA		21,000	200	NA		NA	
		% of run			0.04%	0.00%				

2.17.2 Effect of the Take

In this opinion, NMFS has determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence of the affected species or result in the destruction or adverse modification of critical habitat.

2.17.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are non-discretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

The following reasonable and prudent measures and terms and conditions are necessary and appropriate to: 1) minimize the impacts of incidental take associated with the proposed CRS operation and maintenance (including both operational and non-operational measures), and 2) minimize the impacts of take associated with monitoring and evaluation activities.

1. **CRS operations and maintenance programs.** The Action Agencies shall reduce the impacts of take from proposed CRS operation and maintenance by implementing the measures specified in Section 2.17.4 to reduce take of juveniles and adults.

2. **Tributary and estuary habitat improvement programs.** The Action Agencies shall ensure that the impact of take from CRS operation is minimized by implementing habitat improvement actions as proposed (using appropriate selection criteria, considering priority populations, etc.) and by completing and implementing tributary and estuary habitat RME strategies for the geographic scope encompassed in the proposed action.[453]

3. **Predator management programs.** The Corps and Reclamation shall continue to implement the Caspian Tern Management Plan and Double-crested Cormorant Predation Management Plan at East Sand Island in the Columbia River estuary, and the Inland Avian Predation Management Plan in the interior Columbia River basin to reduce smolt predation rates.

4. **Research, monitoring, and evaluation programs.** The Action Agencies (or their designated contractors conducting the research) shall monitor the level of take of ESA listed species (salmonids and eulachon) associated with specific RME actions and will report the observed take to NMFS' designated CRS take determination coordinator no later than 6 months after the completion of the RME action (i.e., when fieldwork has been completed). Take reports

[453] Incidental take associated with the actual construction and maintenance of individual tributary or estuary habitat improvement projects are authorized under separate biological opinions (e.g., HIP 4). Take resulting from RME activities associated with implementation of the RME strategies is addressed in RMP 4. RMP 2 is intended to ensure that the processes guiding both the project selection processes and the development of a regional RME strategy relating to the tributary and estuary habitat programs are implemented in a strategically sound, effective, and transparent manner.

are also a condition of annual take authorization renewals.

a) The Action Agencies shall minimize the impact of take resulting from the proposed hydrosystem RME actions.

b) The Action Agencies shall minimize the impact of take resulting from proposed habitat RME actions.

c) The Action Agencies shall reduce the impact of take by working with NMFS staff to coordinate research and monitoring activities with other funding and implementing agencies to ensure that necessary data is being collected in a manner that minimizes impacts on listed species. Coordination includes following standardized collection protocols and data sharing. This will reduce take by reducing the potential numbers of fish needed to perform similar research activities.

5. **Monitoring and implementation reporting.** To better understand how to minimize take from activities associated with hydrosystem operations and improve effectiveness of take minimization activities on fish, the Action Agencies will report information related to implementation of the proposed action (which would include activities associated with RPMs 1 through 4). This information supports adaptive management and revision of operations based on information learned. The required information includes take monitoring reports, implementation plans, and implementation progress reports, as outlined in Term and Condition 5 below. This information will provide a record to document implementation of the proposed action and assist NMFS in determining if the proposed action is being implemented in a manner that is consistent with the analysis in this opinion or, conversely, if re-initiation triggers defined in 50 CFR 402.16 have been exceeded.

2.17.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies must comply with them in order to implement the RPMs (50 CFR 402.14). The Action Agencies have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14), including requiring their contractors to comply with applicable terms and conditions when necessary to fulfill a term and condition or its reasonable and prudent measure. If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. **CRS Operations and Maintenance Actions**. To implement reasonable and prudent measure #1, the Action Agencies shall implement the measures below to minimize take from proposed CRS operation and maintenance:

   A. Evaluate Adult Reach Survivals

      i. The Action Agencies shall annually estimate adult survival through key reaches of the migration corridor (Bonneville to Lower Granite dam for Snake River species and Bonneville to McNary Dam for Upper Columbia and Middle Columbia River species) in accordance with the PIT-tag conversion rate methodology used in this Opinion, compare averages of the resulting annual mortality estimates (1-survival) to the values reported in Table 2.17-1, and inform NMFS of the results of this comparison.

B. Evaluate Juvenile Reach Survivals

   i. The Action Agencies, in coordination with NMFS through the annual planning process, shall annually estimate juvenile survival rates of SR spring/summer Chinook salmon, sockeye salmon, and steelhead from Lower Granite to Bonneville dam and UCR spring-run Chinook salmon and steelhead and MCR steelhead from McNary to Bonneville Dam between dams with PIT tag detectors in accordance with the methods used in this opinion. In addition, they will continue to support and fund studies to assess the survival, growth, and life history attributes of wild juvenile Snake River fall Chinook salmon.

C. Monitor Smolt-to-Adult Returns of Transported and Inriver Migrating Fish

   i. The Corps and BPA shall continue ongoing transport survival studies for juvenile migrants passing Lower Granite, Little Goose, and Lower Monumental dams. Updated annual SAR estimates (and daily or weekly estimates if the data allow) for each transported species and their inriver counterparts shall be included in the annual progress reports or by other mutually agreed upon means. This will reduce take by providing the Action Agencies with information to further refine transport operations to optimize operations for Snake River spring and summer migrating fish to improve the survival of transported juveniles (or ESUs/DPSs as a whole).

   ii. The Action Agencies shall coordinate with federal, state, and sovereign parties on the development of a strategy to assess the magnitude of latent mortality associated with juvenile salmonid passage through the CRS projects on the lower Snake River and lower Columbia River and the effectiveness of increased spill as a means of reducing latent mortality (increasing adult returns).

D. Monitor Effects of Dissolved Gas Supersaturation and Ladder Temperatures

   i. The Action Agencies shall monitor TDG (including Grand Coulee, Chief Joseph, and Dworshak Dams, and the lower Snake and lower Columbia River dams) and associated biological impacts in the lower Snake and Columbia rivers in coordination with the mid-Columbia Public Utility Districts. This program will be developed in coordination with NMFS and relevant agencies or partners, and documented in the Water Quality Plan when periodically updated. A TDG monitoring plan will specify monitoring locations, sampling methodologies, calibration and maintenance of monitoring equipment, QA/QC, data collection and reporting, and archival storage in the Corps' online database. The program will also include a biological smolt monitoring component to assess GBT symptoms in smolts at selected smolt monitoring locations, especially between April 3 and June 20 when the flexible spring spill operation is being implemented. TDG pressure and percent saturation, water temperature, and barometric pressure must be sampled on at least an hourly basis. This information, and the results of biological monitoring shall be shared with resource agencies on a near real-time basis. This will reduce take by ensuring that incubating eggs and fry or migrating juvenile and adult salmon and steelhead are not exposed to TDG levels higher than anticipated and that the effects of increased exposure to TDG are not more severe for juvenile and adult migrants than expected.

ii. The Action Agencies shall monitor and report the temperature differentials in all CRS adult fishways. The Action Agencies shall monitor and report the forebay temperature profiles of mainstem lower Snake River and McNary dams. Other temperature monitoring may occur as needed to inform operations and/or designs. This program will be documented in the Water Quality Plan. Temperatures will be sampled on an hourly basis and this information shall be shared with resource agencies on a near real-time basis.

E. Monitor Monthly Project Specific Excursions above the One Percent Peak Efficiency Range for Turbines at Mainstem Snake and Columbia River Dams

i. The Action Agencies shall monitor project specific excursions above the one percent peak efficiency range (both magnitude and duration) for turbine units at individual lower Snake and lower Columbia river dams on a monthly basis. The Action Agencies shall compare these results to the information related to the expected frequencies and magnitudes of these incidents analyzed in this opinion (see USACE et al. 2020). This information should be summarized and reported to NMFS after 3 years of implementing the proposed action, and at least every 3 years thereafter. This information will demonstrate that turbines are being operated above the one percent peak efficiency range within the expected frequencies and magnitudes of exceedances. NMFS shall be notified as soon as possible if the Action Agencies have reason to think these operations are greater than expected.

F. Improve passage conditions for adult sockeye salmon to the extent practicable.

i. Following the extremely high losses of adult sockeye in 2015, NMFS recommended several actions to improve the survival of adult sockeye salmon in the event that similar conditions reoccur. In reviewing these actions, NMFS notes that many of these recommendations have already been adopted and implemented and additional information has been collected with respect to differential temperatures within the adult fishways. To continue this work and further improve fish passage for adult sockeye salmon under high temperature conditions, the Action Agencies shall:

ii. Continue monitoring and reporting of all mainstem fish ladder temperatures and identify ladders with substantial temperature differentials (>1.0°C).

iii. Continue operations at Lower Granite and Little Goose dams to address ladder - tailrace temperature differentials.

iv. Continue to investigate methods to reduce maximum temperatures and temperature differentials in adult fish ladders at mainstem lower Snake (other than Lower Granite and Little Goose Dams) and Columbia dams identified as having these problems, and implement if feasible.

v. Continue to apply water temperature models, or similar tools, to assess the effect of alternative project operations on ladder and tailrace temperatures or implement a study to empirically assess the effect of proposed operations.

iv. Continue to implement and evaluate the Dworshak cold water release program to target temperatures below 18°C at Lower Granite Dam and downstream, if possible, during June and most of July to reduce adult sockeye salmon mortality in the lower Snake River.

G. Reduce Take of Overshoot Adult Steelhead

Relatively large numbers of adult steelhead (e.g., MCR steelhead from the John Day, Umatilla, and Walla Walla River MPGs; and SRB steelhead from the Tucannon River population) overshoot McNary and the lower Snake River dams and then volitionally migrate downstream through the dams to reach their natal streams in the fall and spring. To return to natal streams, these fish often have no passage options other than turbines and screened bypass systems once spill operations for juvenile migrants have ended. This behavior has been repeatedly documented and is identified as a threat in the Snake River and Middle Columbia River steelhead recovery plans. Recent observations in Ham et al. 2019, and detections at the newly operated Lower Granite Dam Removable Spillway Weir (RSW) PIT system suggest that overshoot adult steelhead can pass rapidly once a surface passage route is provided.

To reduce the take of overshooting adult MCR and SRB steelhead the Action Agencies, beginning in 2020, shall implement offseason surface spill as a means of providing safe and effective downstream passage for adult steelhead that overshoot and then migrate back downstream through McNary Dam and the Snake River dams during months when there is no scheduled spill for juvenile passage.

i. Surface oriented spill will be provided from October 1 until November 15 in the fall and from March 1 to March 30 in the spring at each of the five dams.

ii. Surface oriented spill will be provided at least three times each week on non-consecutive days, at each of the five dams.

iii. On the selected days, surface oriented spill will be provided for 4 hours each morning (generally between 5 a.m. and 11 a.m.) through a spillway weir at each of the five dams.

iv. To maintain or further reduce take throughout the duration of the opinion, the Action Agencies, in cooperation with NMFS and other regional co-managers, through the established Regional Forum's adaptive management processes, will regularly evaluate downstream adult steelhead passage information to determine if the timing of surface oriented spill should be altered (e.g., moved earlier or later) or extended (e.g., start operations in September in the fall or February in the spring).

a. Surface spill operations for adult steelhead can be modified through adaptive management processes so long as the proposed operations are equally or more protective.

b. The spillway weirs can be modified to reduce the amount of water spilled through the weir for adult steelhead as long as the proposed structure and operation, together, are equally or more protective.

H. Reduce Take Associated with Elevated Pinniped Predation near Bonneville Dam Fish Ladder Entrances

i. At Bonneville Dam, many adult salmonids experience delay as they attempt to navigate through fishway entrances increasing pinniped predation exposure. Past dam hazing efforts were primarily limited to the spring period when California sea lions were present. In recent years, increasing and substantial numbers of Steller sea lions have been hauling out at Bonneville Dam in the fall and winter and are feeding unabated near fish ladder entrances on steelhead, coho, and fall Chinook ESU's. While hazing has had limited effectiveness compared to removals, the available information indicates dam hazing does temporarily push pinnipeds away from entrances where they are most effective at consuming and delaying adult salmon and steelhead. Steller sea lions are more responsive to hazing efforts than California sea lions. To reduce salmonid take associated with sea lion predators taking advantage of the dam and ladder entrance configuration, the Action Agencies shall implement the following measures:

a. The Corps shall fund and support dam hazing and dissuasion efforts to effectively reduce predation on adult salmon and steelhead at Bonneville Dam. Dam hazing shall be focused on reducing and minimizing the amount of time that individual sea lions spend near ladder entrances. Hazing and dissuasion shall be supportive of pinniped removal efforts and cover the periods from March 31 through May 31 and August 15 through October 31. The Corps, in coordination with NMFS, may adjust the hazing season start and end dates based on factors such as the number of animals present at the dam and hazing effectiveness. The Corps may reduce dam-based hazing efforts as necessary to implement an agreed upon study that evaluates the effectiveness of Steller sea lion hazing and dissuasion. If the results from an agreed upon study indicate that hazing is completely ineffective or if pinniped removals result in effective elimination of pinniped predation at Bonneville Dam, the Corps, in coordination with NMFS, may cease dam hazing and dissuasion efforts.

b. The Corps shall opportunistically haze pinnipeds observed in the vicinity of fish ladder entrances at The Dalles Dam.

I. Reduce Take Associated with the Implementation of the Northern Pikeminnow Management Program and Demonstrate Program's Current Efficacy

i. Available information indicates that relatively high numbers of ESA-listed salmonids are incidentally encountered and recorded as take while electrofishing during implementation of the NPMP. To further reduce take associated with the NPMP, the Action Agencies shall implement the following measures:

a. By 2023, begin alternative sampling methods (e.g., hook-and-line, nets, traps, etc.) or strategies (i.e., reward and derby fisheries which don't require tagging, or only electrofishing when adult and juvenile salmonids are less likely to be present) to reduce take of ESA-listed salmonids during implementation of the sport reward fishery and associated tag-recovery studies, biological evaluations, and critical program goals. This may be a phased approach with full implementation taking 1 to 3 years, depending on the outcome of the Action Agencies' proposed action studies, and is intended to maintain support of the NPMP while reducing take of ESA-listed salmonids.

b. To ensure that the NPMP continues providing predation-reduction benefits, conduct periodic (i.e., 3- to 5-year intervals) evaluations of removal program (i.e., exploitation rate analyses), and update consumption models using the best available science including estimates of inter- and intra-specific compensation (including avian species), as feasible.

J. Fish Status and Trend Monitoring

To better understand how to minimize take from activities associated with hydrosystem operations and improve effectiveness of take minimization activities on fish, the Action Agencies shall continue monitoring the status of listed salmonids that are affected by the operation of the CRS:

i. The Action Agencies shall support continued fish population status and trend monitoring where ongoing status and trend programs are located and linked to overall population viability assessments, including supporting adult abundance monitoring in tributaries as a component of fish population status and trend monitoring in as many populations as possible.

a. The Action Agencies shall continue to advance the deployment, development and testing of new and emerging tools, techniques and methods that assist with status and trend monitoring such as GSI and PBT.

b. The Action Agencies shall improve the distribution and quantity of steelhead monitoring throughout the basin.

ii. The Action Agencies shall support continued fish population status and trend monitoring where ongoing status and trend programs are located and linked to overall population viability assessments, including supporting adult abundance monitoring in tributaries as a component of fish population status and trend monitoring in as many populations as possible.

iii. The Action Agencies shall coordinate and implement, if feasible and effective, measures (e.g., experimental barge detection technology, increased estuary trawl detections, etc.) to improve the accuracy of McNary Dam to Bonneville Dam reach survival estimates for UCR spring-run Chinook salmon and steelhead compared to 2017-2019 estimates.

K. Identify, Review, and Prioritize Fish Passage Related Maintenance Issues

When operating properly, fish passage structures generally provide safe and effective passage of both juvenile and adult salmon and steelhead at the lower eight mainstem CRS dams. Maintenance of these structures and systems is critical for their long-term reliability and the provision of safe and effective passage. To further reduce take associated with the maintenance of existing fish passage structures or operations:

i. The Action Agencies shall annually review critical failures that have interrupted operations from adhering to Fish Passage Plan criteria, and make recommendations for the prioritized non-routine fish passage structure maintenance needs by project prior to the next budget request.

ii. Before September (of each year), prior to developing budget requests for the following spring, the Corps shall seek input from FPOM to aid Action Agency prioritization of non-routine repairs to critical infrastructure that supports fish passage system operability.

iii. The Action Agencies shall develop, in coordination with NMFS, a prioritized list of maintenance issues critical for the reliability of fish passage systems at the mainstem dams, and use this list to consider how to prioritize the use of Operations and Maintenance funds, to the extent possible.

2. **Tributary Fish and Habitat RME Activities**. To implement reasonable and prudent measure #2, the Action Agencies shall demonstrate that proposed tributary habitat improvement actions are being implemented as expected and that the effects of the actions are occurring as expected by completing and implementing a habitat RME strategy for the geographic scope encompassed in the proposed action:

A. Compliance and Implementation. The Action Agencies shall conduct and support tributary habitat compliance and implementation monitoring in priority tributaries where actions are implemented during the period of this opinion to assist in measuring and evaluating the benefits of off-site actions.

B. Effectiveness. The Action Agencies shall support effectiveness monitoring at the site, watershed and basin scales in priority tributaries where habitat actions are implemented during the period of this opinion and within tributaries where previous actions have been undertaken.

C. The Action Agencies shall implement 'fish in/fish out' monitoring for focal populations where, through coordination with NMFS, it is determined appropriate to link habitat actions and their effectiveness with fish productivity and survival.

D. Coordination. The Action Agencies shall work with NMFS and the region's fish and wildlife managers, through the Columbia Basin RME steering committee, to develop the Columbia Basin Tributary Habitat Research Monitoring and Evaluation Strategy including the prioritization of watersheds for continued and new Intensively Monitored Watershed, joint fish population status and trend monitoring, and 'fish in/out' monitoring to assist in measuring and evaluating the benefits of off-site actions.

E. Reporting. The Action Agencies shall report on the results of the compliance, implementation, effectiveness monitoring, and paired habitat with "fish in/fish out" and fish population status and trend monitoring.

3. **Predator Management.** To implement reasonable and prudent measure #3, the Corps shall continue to implement the Caspian Tern Management Plan and Double-crested Cormorant Predation Management Plan at East Sand Island in the Columbia River estuary, and Reclamation shall continue to implement the Inland Avian Predation Management Plan in the interior Columbia River basin. The Action Agencies shall continue to evaluate the effectiveness of the proposed management plans in reducing smolt predation rates by implementing the following measures:

   A. Following completion of the Avian Predation Synthesis Report (expected in September 2020), the Action Agencies shall reassess the need to continue to fund PIT-tag recoveries, PIT detection probabilities, and other activities. For example, the Avian Predation Synthesis Report may show that predation rates can be based on peak colony counts and past per-capita consumption rates with approximately the same precision and potential bias as empirically derived rates. Or numbers of Caspian terns and double-crested cormorants at these sites may be so low due to management activities and other demographic processes (e.g., birds move to areas outside the Columbia River basin) that predation rates are less important. The Action Agencies shall coordinate decisions about whether to fund PIT-tag recoveries, PIT-tag detection probabilities, or other activities needed to obtain empirical estimates of predation rates with NMFS and the regional co-managers that participate in the Regional Forum FPOM Workgroup.

B. The Action Agencies shall consider the recommendations in the final Avian Predation Synthesis Report and assess whether there are additional actions that could be taken, within their authorities, to further reduce salmon and steelhead mortality from avian predation.

4. **RME Take Avoidance and Minimization.** To implement reasonable and prudent measure #4, the Action Agencies (or their designated contractors conducting the research) shall implement the following to minimize the impact of take associated with the proposed action:

A. The Action Agencies shall minimize take by working with NMFS staff to coordinate research and monitoring activities they fund with those of other funding and implementing agencies. This is to ensure that necessary data are being collected in a manner that minimizes overall disturbance to fish and reduces the impacts on listed species.

B. The Action Agencies shall continue to support monitoring and coordination forums and other efforts that the region's tribes, state agencies, other Federal agencies, NGOs and other entities participate in to coordinate monitoring actions.

C. The Action Agencies shall minimize the impact of take resulting from the proposed RME actions by implementing the following measures:

Fish listed under the ESA must be handled with extreme care and kept in water to the maximum extent possible during sampling and processing. Adequate circulation and replenishment of water in holding units is required. When using gear that captures a mix of species, ESA-listed fish must be processed first, to the extent possible, to minimize the duration of handling stress. ESA-listed fish must be transferred using a sanctuary net (which holds water during transfer) whenever practical to prevent the added stress of being out of water. Should NMFS determine that a researcher's procedure is no longer acceptable; the researcher must immediately cease such activity until an acceptable alternative procedure can be developed with NMFS.

i. Researchers must not intentionally kill or cause to be killed any listed species unless a specific monitoring or evaluation proposal, approved by NMFS, specifically allows intentional lethal take.

ii. Each researcher must ensure that the ESA-listed species are taken only by the means, in the areas, and for the purposes set forth in the research proposal, as limited by the terms and conditions.

iii. Each ESA-listed fish handled out of water must be anesthetized to prevent injury.

iv. Anesthetized fish must be allowed to recover (e.g., in a recovery tank) before being released. Fish that are simply counted but not handled must remain in water, but do not have to be anesthetized. Whenever possible, unintentional mortalities of ESA-listed fish that occur during scientific research and monitoring activities shall be used in place of intentional lethal take.

v. Workers must use a disinfected needle for each individual injection when PIT tags are inserted into listed fish.

vi. Each researcher, in effecting the take authorized by this incidental take statement and through NMFS's Take Determination letters, is considered to have accepted the terms and conditions of this incidental take statement and any additional terms or conditions required by NMFS's Take Determination letters.

vii. Each researcher is responsible for the actions of any individual operating under the authority of the researcher's designated take authorization.

viii. Each researcher, staff member, or designated agent acting on the researcher's behalf must possess a copy of the incidental take statement in this opinion and the NMFS authorizing take determination letter.

ix. Researchers may not transfer or assign incidental take within this determination to any other person(s).[454] The take authorization ceases to be in force or effective if transferred or assigned to any other person without prior authorization from NMFS.

x. Each researcher must obtain any other Federal, state, and local permits or authorizations necessary to conduct the activities provided for in this incidental take statement.

xi. Each researcher must coordinate with other applicable co-managers and researchers to avoid unnecessarily duplicating effort and increasing the adverse cumulative effects that may result from the researcher's activities.

xii. NMFS reserves the right to inspect research activities as they occur. This may include observation or review of research activities, facilities, records, etc. pertaining to ESA-listed species covered by this determination, the incidental take statement or the biological opinion.

xiii. Any researcher violating any applicable condition of this incidental take statement will be subject to any and all penalties as provided by the ESA. NMFS may revoke a researcher's authorization for any activities not conducted in compliance with the requirements of the ESA.

xiv. Each researcher is responsible for biological samples collected from ESA-listed species as long as they are useful for research purposes. The terms and conditions concerning any samples collected remain in effect as long as the researcher maintains authority over and responsibility for the material taken. A researcher may not transfer biological samples to anyone not listed in the research proposal without obtaining prior written approval from NMFS. Any such transfer will be subject to such conditions as NMFS deems appropriate.

xv. NMFS may amend a take authorization identified in this incidental take statement or

[454] A person as defined in Section 3(12) of the ESA.

adjust specific take levels after reasonable notice to the applicable researcher.

xvi. If the activities authorized in this incidental take statement are not carried out in accordance with its terms and conditions and the purposes and requirements of the ESA, or if NMFS otherwise determines that the continuation of activities would operate to the disadvantage of ESA-listed species, NMFS may revoke a take authorization identified in this incidental take statement.

D. The Action Agencies shall minimize the impact of take resulting from proposed habitat, hatchery, and status RME actions by implementing, in addition to those applicable measures in 4.b., the following measures:

i. The Action Agencies must obtain NMFS's review and approval of any monitoring and evaluation plans before initiating any research-related activities. These plans must identify annual anticipated take levels.

ii. Generally, workers must stop handling listed juvenile and adult fish if the water temperature exceeds 70°F at the capture site. Under these conditions, listed fish may only be visually identified and counted. Additionally, electrofishing is not permitted if the instantaneous water temperature exceeds 64°F.

iii. If workers incidentally capture any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

iv. If backpack electrofishing methods are used, workers must comply with NMFS' Guidelines for Electrofishing (NMFS 2000) available at http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf.

v. Backpack and boat electrofishing electrofishing is not permitted if listed adult salmon or steelhead are known to be present. Any listed adult salmon or steelhead encountered while electrofishing are considered take, even if it is allowed to swim away without any further interaction or handling, and must be reported as such in the annual report. The Northern Pikeminnow Management Program is currently exempted from this rule. Future plans for the program's electrofishing efforts are described in further detail above (Section 2.17.1.5, Amount or Extent of Incidental Take from RME Actions) and in each species chapter.

vi. The Action Agencies must obtain approval from NMFS before changing sampling locations or research protocols.

vii. Implement the following measures when implementing escapement/redd surveys:

a. Except for escapement (redd) surveys, no in-water work will occur within 300 feet of spawning areas during anadromous fish spawning and incubation times.

b. Persons conducting redd surveys will be trained in redd identification, likely redd locations, and methods to minimize the likelihood of stepping on redds or delivering fine sediment to redds.

c. Workers will avoid redds and listed spawning fish while walking within or near stream channels to the extent possible. Researchers will examine pool tail outs and low-gradient riffles for clean gravel and characteristic shapes and flows before walking or snorkeling through these areas.

d. If redds or listed spawning fish are observed at any time, workers will step out of the channel and walk around the habitat unit on the bank at a distance from the active channel.

viii. Snorkel surveys will follow a statistically valid sampling design.

ix. Researchers will minimize effects on any given stream or riparian buffer area by avoiding numerous repeat visits to sampled sites to the degree practicable.

5. **Monitoring Reports, Implementation Plans and Reports, and Notification Requirements** To implement reasonable and prudent measure #5, the Action Agencies (or their designated contractors conducting the research) shall submit monitoring reports, implementation plans, and implementation progress reports.

ESA Incidental Take Authorizations / Reports and Other Monitoring Reports:

A. The Action Agencies will report numbers of adult eulachon observed in samples from the juvenile bypass system at Bonneville Dam, and will provide this number to NMFS on an annual basis (within the calendar year).

B. Annual ESA take authorization applications and annual ESA take monitoring reports and for all RME programs identified in this incidental take statement (including the SMP/CSS and the NPMP) shall be submitted using the Authorization and Permits for Protected Species (APPS) online reporting system (https//apps.nmfs.noaa.gov) or other reporting system as designated by NMFS. Submission and approval of an ESA take authorization application using the APPS system is required before any RME project or program may begin work in the field. A project or program's ESA take monitoring report is to be completed within 6 months from when fieldwork has been completed, or by December 1 (whichever is earliest); a take monitoring report is also a requirement for renewal of the project's or program's take authorization the following year.

i. The ESA take authorization application shall include the following:

a. Project purpose and relatedness to objectives of this opinion.

b. Project sampling design and analysis methods.

c. Project dates and location(s).

d. The total number of ESA-listed fish estimated to be taken (with separate handling and mortality estimates) at each location and by ESU/DPS, life stage, origin (hatchery or natural-origin), and the manner of take (capture method and sampling methods).

e. Names and affiliations of authorized researchers.

f. Project contact information.

g. Signed authorization letter.

ii. The ESA take reports shall include the following:

a. A detailed description of scientific research and monitoring activities, including the total number of ESA-listed fish taken at each location (with separate total handled and total mortality counts) and by ESU/DPS, life stage, origin (hatchery or natural-origin), and the manner of take (capture method and sampling methods).

b. Measures taken to minimize disturbances to ESA-listed fish and the effectiveness of these measures, the condition of ESA-listed fish taken and used for research and monitoring, a description of the effects of research and monitoring activities on the subject species, the disposition of ESA-listed fish in the event of mortality, and a brief narrative of the circumstances surrounding fish injuries or mortalities to ESA-listed fish.

c. Any problems that arose during research and monitoring activities, and a statement as to whether the activities had any unforeseen effects.

d. Steps that have been and will be taken to coordinate research and monitoring activities with those of other researchers.

C. The Corps and BPA shall continue to annually report on their findings regarding the effectiveness of the proposed Caspian Tern Management Plan and Double-crested Cormorant Predation Management Plan at East Sand Island in the Columbia River estuary, and the Inland Avian Predation Management Plan in the interior Columbia River basin.

Implementation Plans:

A. The Action Agencies shall submit to NMFS implementation plans that detail commitments for hydrosystem, tributary and estuary habitat improvements, predator management, and RME:

i. A Fish Passage (including Fish Operations) Plan for hydrosystem structures and operations will be completed annually by March 31 for spring migrants and June 15 for summer migrants.

ii. A Water Management Plan will be completed annually by January 1.

iii. A Total Dissolved Gas Report will be provided to NMFS annually following submission to the state water quality agencies.

iv. As outlined in the proposed action, the Action Agencies will develop, with input from NMFS, a series of prospective 5-year implementation plans for tributary habitat actions. The first 5-year implementation plan will be due in March 2021 and successive plans due at 5-year intervals thereafter. The Action Agencies will work with the Tributary Habitat Steering Committee (THSC), with input from the Tributary Technical Team (TTT), to develop information requirements for these reports. The requirements may change over time by agreement of the THSC as understanding evolves of how the information can be useful not only to ensure that the information provided serves to confirm that the Action Agencies are meeting the commitments in the proposed action but also to inform adaptive management and evaluation of the program's benefits.

a. Within the first year of implementation of the proposed action, the THSC, with approval by Bonneville, Reclamation, and NMFS, will develop specific operating rules, charter, membership, and time requirements for the TTT.

v. The CEERP's Restoration and Monitoring Plan (annually, no later than May 15).

vi. Avian Predation Management and Monitoring Plan (provide lists of actions including rationale and monitoring plans by bird species and location annually, no later than January 31).

vii. Northern Pikeminnow Management and Monitoring Plan (provide lists of actions including monitoring annually, no later than March 1). However, field work and sampling operations cannot commence until an annual take application (including the monitoring plan) is submitted and authorized by NMFS via the Authorization and Permits for Protected Species (APPS) website (https//apps.nmfs.noaa.gov) as noted above under "ESA Take Authorizations / Reports and Other Monitoring Reports".

viii. Pinniped Management and Monitoring Plan (annually, no later than April 15 and March 1).

ix. Fish Status RME Plan (identify populations/water bodies that will be sampled by the Action Agencies' partners annually, no later than May 15).

The implementation plans or alternative materials will take into account pertinent new information from past years' monitoring as well as new information on the effects of climate change on limiting factors with the potential to affect project priorities.

Implementation Progress Reporting:

A. The Corps shall report progress in implementing the Fish Passage Plan in a timely manner; providing 7-day Corps project adult/juvenile facility reports (including ESA and non-ESA fish mortalities) and 7-day fish transportation summaries to NMFS and FPOM via electronic mail once a week. In addition, the Corps shall provide facility reports and transportation summaries to NMFS and FPOM once a year in electronic format.

B. The Action Agencies shall annually report to NMFS by February 15, on the progress of action implementation, beginning with 2020 spring operations. Implementation progress reporting shall include standard information on the progress of hydrosystem operations, predator management programs, estuary habitat actions, and tributary habitat actions. Progress reports can be formal reports, or in the form of other materials, including email, that describe expected activities in adequate detail.

C. The Action Agencies shall monitor TDG levels in representative raceways and barges to assess the effect of increased TDG levels resulting from proposed flexible spill operations to ensure that transported juveniles are being safely collected and transported.

D. As outlined in the proposed action, the Action Agencies will report annually on tributary habitat improvement actions implemented, and at 5-year intervals they will complete a more comprehensive review of actions implemented. Actions implemented will be reported for populations and major population groups annually, with the assessment of population-level accomplishments utilized to inform program adaptive management during 5-year comprehensive reviews. Within 4 months of beginning implementation of the proposed action, the THSC will agree on deadlines for submission of annual implementation reports and the 5-year comprehensive reviews.

E. The 5-year comprehensive reviews will provide information sufficient to inform the assessment of the biological benefits of the program both qualitatively and quantitatively (e.g., through life-cycle modeling). Reporting shall include the following information for each action implemented, unless these requirements are modified through discussion with and concurrence by NMFS:

    i. Location and extent of action: Provide GPS coordinates for midpoint, start, and endpoint of action. For barrier remediation, provide point of barrier, and extent of benefits from the action; for flow actions, provide location of input and extent of the stream benefits from the action.

    ii. Action category: Provide action category using the standard categories used in the 2008 biological opinion and its 2010 and 2014 supplements: flow enhancement/protection; habitat complexity; riparian area restoration; access; screening. (A single action may address more than one category.)

    iii. Action description: Provide a brief narrative description of the action, including a more detailed description of project type—for example: access (barrier removal); complexity (direct channel modification, passive restoration, dike removal/setback, large wood placement, etc.)

    iv. Action rationale and objectives: Describe the objectives and rationale for the action, including the following: What was the basis for choosing the action type and location? What protocol was used to design/implement the action? What were the objectives in terms of changing habitat (these will differ by action type—see examples below):

        a. Example habitat change objectives (in terms of relevant habitat conditions):

- Estimated change from non-pool to pool habitat (e.g., in m^2).
- Increased sinuosity from current (altered) toward natural (e.g., 1.0 to 1.5).
- Flow (CFS) restored to reach (upper river km to lower km; for what time period; seasonal or annual).
- LWD/boulder/rock weir placement (amount, placement protocol, stream structure change objective).
- Riparian restoration: if active—species used, restoration buffer width description, density.
- Dike removal/setback: general description (or a simple map) of extent of intended removal/setback in the target reach. Preliminary estimate of the amount of floodplain habitat that would be reconnected. Description of expected side channel/alcove access versus current.
- Special case effects: actions aimed at reducing specific sources of mortality (e.g., predator or predator exposure reductions).

a. Implementation timing: (e.g., 1-year design, 2 years to implement).

b. Target reach current habitat condition: Provide or cite a reference document/database if available. Ideally should describe current habitat conditions relative to some optimum level of function.

c. Target reach post-implementation habitat conditions: How did the habitat change as a result of action implementation? Metrics will differ by project type but, e.g., CFS restored, in what season and for what length of time; how many large wood jams; how many pools created; etc.

d. For tributary habitat RME, report on activities, categorized by method and by WRIA, USGS 6th field HUC, and UTM or other appropriate spatial point information. Other relevant metrics will be identified in conjunction with the THSC, the Tributary Technical Team and through the development of the Tributary Habitat RME strategy.

During the first year of implementation of the proposed action, the THSC, in collaboration with the TTT, will coordinate the final requirements for both the annual and the 5-year comprehensive reviews of habitat implementation, and will assure that reporting objectives are met. Details of the metrics and narrative information reported and the format and protocols for reporting will be developed by the THSC in coordination with the TTT and will be updated periodically.

Operational Reporting and Notification Requirements (for Protocol Change Requests and Take Limit Exceedance):

i. Researchers must obtain NMFS's approval prior to implementing research protocols (e.g., changes in sampling locations or fish handling protocols) that differ from those considered in the Take Determination letters, unless immediate deviation from these same protocols are necessary to reduce impacts to fish in hand. In this case, researchers must contact NMFS' designated Take Coordinator or other designated staff as soon as possible to report on the situation (including reporting any resultant unexpected take), the actions taken by the research to minimize impacts to research fish, and coordination of additional actions that are necessary before the research can continue.

ii. Each researcher must alert NMFS whenever the authorized level of take is exceeded, or if circumstances indicate that such an event is imminent. Notification shall be made as soon as possible, but no later than 2 days after the authorized level of take is exceeded. The researcher must then submit a detailed written report to NMFS. Pending a review of the circumstances, NMFS may suspend the research and monitoring activities.

iii. Each researcher must alert NMFS when a take of any ESA-listed species not included in the research proposal is killed, injured, or collected during the course of research and monitoring activities. Notification shall be made as soon as possible, but no later than 2 days after the unauthorized take. The researcher must then submit a detailed written report to NMFS. Pending a review of the circumstances, NMFS may suspend research and monitoring activities.

2.18 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. **Support ongoing regional discussions with sovereigns and stakeholders to develop and implement future collaborative conservation approaches to rebuild listed fish populations in the Columbia River Basin.**

   NMFS recommends that the CRS action agencies continue to participate in ongoing discussions with regional sovereigns to maintain a collaborative forum where federal agencies can join with sovereigns and regional stakeholders to develop and implement conservation efforts. This approach provides a viable and constructive way to break down traditional barriers and understand and address the perspectives of the many different parties. It is recognized that CRS action agency implementation of actions resulting from this collaboration will be limited by the CRS action agencies' authorities, as well as their statutory and regulatory responsibilities.

   A collaborative forum could build upon the successful elements of the Columbia Basin Partnership (CBP) Task Force for rebuilding salmon and steelhead populations in the Columbia River basin and make progress towards achieving the broad-scale goals they identified.

   Regional sovereigns and stakeholders participating in the CBP Task force, convened by the Marine Fisheries Advisory Committee, an advisory committee for NMFS, have identified salmon and steelhead goals that go far beyond recovering the species under the Endangered Species Act and would support a diverse range of biological, social, cultural, economic, and ecological values for the region.

   The CBP Task Force promotes a comprehensive approach by addressing the geography of the salmon life-cycle from their upland spawning habitats to the ocean, and back again. This allows consideration of the full range of biological factors affecting salmon survival, not just those associated with the hydro system.

   The Task Force members see great value in continuing their comprehensive collaboration into the future, recognizing the unique opportunity such collaboration could provide to advance salmon rebuilding and sustainability. They have identified the importance of a path forward that would provide a unique venue for stakeholders to work collectively with federal, state, and tribal managers. Such a diverse membership can bring together expertise, knowledge, and wisdom from across social, cultural, economic, and ecological interests across the basin. The collaboration helps to form a critical bond among broader constituencies and communities in the basin. Finally, the commitment to work together creates a powerful foundation for future collaboration. Therefore, NMFS recommends that the action agencies continue to participate in regional discussions to maintain the momentum created by the CBP and other regional groups as the different parties consider the next steps around regional collaboration to continue to make progress on these important issues.

2. **Evaluate system operations, in consideration of potential climate change effects, to maintain or enhance spring and summer mainstem migration and passage conditions for adult and juvenile salmon and steelhead.**

   System operations have evolved over time to enhance conditions for migrating adult and juvenile salmon and steelhead in the mainstem migration corridor. These operations include minimizing drafts to those necessary for flood risk management, augmenting flows through releases of stored water, and the development of the "Dry Year" strategy. However, the development of new water management strategies may be necessary to address altered patterns in seasonal flows stemming from regional climate change effects, and their effects on migrating juvenile and adult salmon.

   The Action Agencies should use available processes, in coordination with regional co-managers (including NMFS) to explore the potential of enhancing system-wide operations to further improve conditions (flows, temperatures, etc.) in the mainstem migration corridor for salmon and steelhead. Potential operations to buffer projected climate change effects should be a special focus.

   A. Explore potential operations with regional partners, including public utility and irrigation districts.

   B. The U.S. Entity should consider climate change and opportunities to improve conditions for salmon and steelhead during implementation of the Columbia River Treaty.

3. **Reduce mortality associated with Dworshak Dam turbine maintenance and testing**

   A. Each turbine unit at Dworshak Dam requires annual preventative maintenance to maintain operational condition. The annual maintenance period is September 15 through the end of February to coincide with the refill period after summer flow augmentation and before flood control operations begin. Annual maintenance is typically performed one unit at a time and requires the unit to be out of service for 2–6 weeks. During the annual maintenance period, Snake River steelhead adults are present in the tailrace at Dworshak Dam, and mortalities associated with maintenance operations have been documented. It is currently believed that the steelhead are attracted to the flow conditions and are swimming up the draft tube during starts and stops or speed no-load operations and can experience strike and decapitation by making contact with the Francis blades spinning at high velocity (Renholds et al. 2019). To reduce mortality of SRB steelhead, the Action Agencies should implement the following measures:

      i. Operate within the guidance provided in the Fish Passage Plan. Continue to use the available information and modify the protocol as necessary to avoid further mortalities.

a. A biologist or trained observer should estimate and record the number of adult salmonids killed or injured during starts and stops and speed no-load maintenance operations. Record time, date, and duration of speed no-load operation along with mortality and injury observations. Identify or estimate the species and origin of mortalities as possible, and report information to NMFS and FPOM.

b. If mortalities continue, construct cost effective physical barriers similar in concept to the alternative selected in Renholds et al. (2019) to prevent future adult SRB steelhead take during testing and maintenance operations.

4. Evaluate alternative transport operations to increase adult returns of Snake River salmon and steelhead.

The available information clearly indicates that: 1) adults that were transported as juveniles stray at higher rates than those that migrated inriver as juveniles, and increased straying tends to occur most frequently in the lower Columbia River downstream of McNary Dam, and 2) the relative benefit of transportation varies seasonally for SR spring-summer Chinook salmon, SR fall Chinook salmon, and SRB steelhead. Straying has been identified as an issue for both donor and recipient populations in multiple recovery plans. Alternative transport operations have the potential to increase the productivity of transported fish (and thereby, Chinook salmon and steelhead populations throughout the Snake River basin) by reducing stray rates or addressing other factors related to transportation that may limit survival to spawning.

A. The Action Agencies should work with NMFS and regional partners to develop and implement a study evaluating "transport pauses" (slowing the barges at the mouths of rivers as juvenile salmon and steelhead are transported downstream) as a means of increasing homing fidelity of transported SR spring-summer Chinook, steelhead, and sockeye salmon.

   i. The study should specifically consider the potential influence of important stream junctures (Columbia and Snake, Columbia and Deschutes, etc.) in the design.

   ii. This study should specifically consider available information to determine the number of hours of delay (and the number of locations where pauses would occur) that would be needed to reasonably assure improved juvenile imprinting would be likely.

   iii. This study should consider monitoring requirements needed to determine if implemented measures are effective (i.e., straying rates are reduced).

   iv. This study should evaluate the condition and survival of smolts in the barge holds when exposed to high levels of TDG for extended periods, and should evaluate potential differences in survival between older and newer types of barges

B. The Action Agencies should work with NMFS and regional partners to review information evaluating the effects of eliminating transport in June and July (when few spring/summer Chinook salmon are present and the benefit of transport for juvenile fall Chinook salmon is variable).

i. This review should specifically consider potential negative effects on yearling spring/summer Chinook salmon, sockeye salmon, or steelhead smolts; and avoid potentially substantial effects to the extent practicable.

ii. This review should consider monitoring requirements needed to determine if implemented measures are effective (i.e., straying rates are reduced; returns of adults migrating as subyearling smolts are generally improved).

5. **Evaluate Relatively Low Juvenile Survival Rates at the Bonneville Dam Spillway**

Available information indicates that estimated survival rates of juvenile salmon and steelhead passing through the spillway at Bonneville Dam are consistently lower than at other mainstem projects. Increasing spill levels at this project, as proposed, increases the proportion of juvenile salmon and steelhead passing the project via the spillway. To reduce mortality associated with spillway passage at Bonneville Dam, the Action Agencies should implement the following measures:

A. Investigate and identify, to the extent practicable, likely cause(s) of relatively low survival of spillway passed juveniles. Potential issues that might contribute to relatively low survival through the spillway may include sheer associated with spillgate design, physical injury due to relatively small gate openings, predation, or adverse physical conditions in the tailrace.

B. Following completion of the investigation, the Action Agencies, in cooperation with NMFS and co-managers, should implement structural or operational measures, if deemed feasible and effective, to increase survival through this route of passage.

C. The Action Agencies, using established regional processes, should develop a study to assess the efficacy of structural or operational measures, including passage times and survival rates of juvenile yearling Chinook salmon and steelhead migrating through the Bonneville Dam spillway.

6. **Evaluate issues and potential actions to improve the reliability or performance of fish passage structures and operations**

There are many potential actions that, once evaluated and implemented, could improve the reliability or performance (increase fish survival, reduce travel times or stress, etc.) of fish passage systems. The Action Agencies should evaluate actions that could achieve this outcome. The actions should include, but not be limited to, the following:

A. The effect of alternative spill operations on juvenile yearling Chinook salmon and steelhead survival, travel times, and routes of passage.

B. Prioritize maintenance for fish passage elements that were in place during the performance testing process. The Bonneville sluiceway end-gate is an example of elements that are important for fish survival but are non-operational. The Action Agencies should request project funding as needed to maintain critical fish passage infrastructure that was operable during performance standard testing.

C. Maintain and improve conditions in the Lower Granite Trap and Bonneville Adult Fish Facility to reduce stress and risk to adult salmon and steelhead.

D. Continue monitoring for PIT tags at avian colonies near the mainstem Columbia River dams.

7. Investigate and potentially reduce northern pikeminnow predation at mainstem CRS dams.

Available information indicates that northern pikeminnow congregate near the mainstem CRS dams to prey on juvenile salmonids. At some projects, dam angling programs have not been implemented for many years, possibly allowing northern pikeminnow to increase in numbers in these areas (increasing predation). To enhance the effectiveness of the dam angling, and thereby further reduce predation associated with northern pikeminnow predators at the mainstem dams, the Action Agencies should implement the following measures:

A. Evaluate the effectiveness of focused removals of northern pikeminnow at Columbia and Snake River dams to investigate the cost and benefits of dam angling in increasing juvenile salmonid survival.

B. Using the existing dam angling program, rotate dam angling crews to mainstem CRS dams to identify if predation hotspots have developed and investigate northern pikeminnow presence and size.

C. Develop a standardized metric such as catch per unit effort (CPUE) indices and compare to existing presence data at The Dalles and John Day Dams. Compare and report metrics including CPUE, total catch, and the size range of northern pikeminnow.

D. Report metrics of any incidentally caught non-native piscivorous species. Coordinate with NMFS to determine if future adjustments to the current dam angling program would reduce mortality of ESA-listed salmonids.

8. Investigate, develop, and implement PIT tag detection improvements at key CRS dams and in the lower Columbia River and estuary as necessary to maintain or improve survival estimates.

Increasing spill levels at CRS Dams, on average, reduces both the number of PIT tag detections and the proportion of juveniles detected, which reduces the accuracy and precision of juvenile reach survival estimates. In addition, the “estuary trawl” used to obtain PIT tag detections critical for assessing survival to Bonneville Dam is expensive, time consuming, and not without human safety risks. The Action Agencies should cooperate with NMFS and regional co-managers to assess the potential to utilize expanded PIT tag detector platform capabilities to enhance PIT tag detections at key dams and, if feasible and effective, replace the estuary trawl with alternative PIT tag detection system(s).

A. Install a PIT detection system in the Bonneville Ice and Trash Sluiceway.

B. Investigate and install, if feasible, a PIT detection system at McNary Dam that improves the Snake River reach survival estimate by detecting a portion of spillway passed fish.

C. Investigate, and implement if feasible, increased PIT tag detection capabilities in the lower Columbia River and estuary (pile dike detectors, flexible loop detectors, PIT barges, avian detections, etc.) that could, over time, replace the estuary trawl as the primary means of obtaining PIT detections necessary to make survival estimate at Bonneville Dam.

9. Evaluate losses of juvenile salmon and steelhead between their natal tributaries and the mainstem lower Snake and Columbia River dams and reservoirs.

Large proportions of juvenile salmon and steelhead are lost between PIT tag detectors in tributary streams and those at mainstem lower Snake and Columbia dams. In some cases, these losses far exceed those observed for juvenile migrating through the mainstem reaches (Widener et al. 2018). Understanding the mechanisms causing these losses could lead to the development of effective actions that would substantially improve the survival and productivity (and the conservation value of designated critical habitat) for numerous salmon and steelhead populations.

A. The Action Agencies should cooperate with NMFS and regional co-managers to develop and implement studies that would identify where, within tributary streams, large numbers of juveniles are being lost, and the mechanism causing these losses.

B. The Action Agencies should cooperate with NMFS and regional co-managers by sharing information, expertise, or funding to enhance our collective understanding of this issue and the means by which it might be addressed.

10. Evaluate potential for improving tributary habitat productivity in populations in the Middle Fork Salmon River spring Chinook salmon MPG.

Habitat in the Middle Fork Salmon River spring Chinook salmon MPG is generally of high quality due to the preponderance of wilderness areas and other Federal lands, and there appears to be relatively low potential for improving habitat productivity in most populations in this MPG. However, as noted in the ESA recovery plan (NMFS 2017e), further exploration of ways to improve habitat is warranted. The potential of the following actions to improve freshwater productivity in the populations in this MPG should be evaluated:

A. Continued efforts to address localized impacts of past land uses.

B. Reintroduction of beaver in populations with significant marsh habitat.

C. Nutrient supplementation.

D. Management of non-native brook trout and other invasive species to improve the function (productivity and capacity) of spawning and rearing habitat.

11. Develop and implement a Columbia Basin Research, Monitoring, and Evaluation Framework consisting of strategies for each of all the major categories of RME work, including: Tributary Habitat, Fish Status and Trends, Hatcheries, Harvest, Estuary and Ocean, Mainstem River, and Hydropower systems.

Research, monitoring and evaluation is the primary means by which data is gathered, analyzed and formulated into usable information about the performance and magnitude of impact that the Action Agencies' actions designed to benefit listed fish species attain. A robust program of RME has been carefully developed and implemented over the past 12 years throughout the geographic scope of the proposed action. Because it is a fundamental principle of an adaptive management approach to make adjustments, many adjustments have been made to these RME programs over this time span. However, consistency and durability of programs, robust protocols, methods and analyses and regularity and repeatability are all critically important to generating reliable information for key management decisions and to objectively evaluate the level of success of actions that are undertaken.

Over the life of this opinion, the Action Agencies should demonstrate that proposed tributary habitat improvement actions are being implemented as expected and that the effects of the actions are occurring as expected by reporting on compliance, implementation, and overall effectiveness. The primary mechanism to attain this information and to generate an understanding of the level of confidence is by-way-of continuing to support monitoring the status of listed salmonids and the effectiveness of the proposed action. In order to advance and improve the Action Agencies' knowledge base in an adaptive management framework, priority regionally agreed upon adjustments to that monitoring should occur following the development of an RME framework and individual thematic strategies (e.g., tributary habitat, estuary and ocean, hatcheries, etc.). As such, the Action Agencies should work with NMFS and regional partners to:

A. Establish an implementation plan for the Columbia Basin Research Monitoring and Evaluation Framework and schedules for development of the associated strategies during the term of this opinion.

B. Work with NMFS, the tributary habitat technical team, and the Columbia Basin RME program to refine the focal population and tributary habitat action areas over the term of this opinion and to ensure alignment between priority monitoring with priority actions.

C. Refine the fish population status and "fish in/fish out" monitoring approaches and prioritize needs for "fish in/fish out" and status and trend monitoring that is representative of populations and habitats throughout the Columbia River basin.

D. Make any adjustments that are contemplated to the existing fish population status and trends monitoring network following completion and through the roll-out of the Fish Population strategy within the Columbia Basin Research Monitoring and Evaluation

Framework developed during the term of this opinion.

12. **To promote eulachon conservation and address uncertainties regarding changes in the hydrograph of the Columbia River and adverse effects on eulachon productivity and abundance, the Action Agencies should:**
    A. Monitor eulachon abundance in the Columbia River via annual spawning stock biomass surveys.

13. **To promote eulachon conservation and address uncertainties regarding changes in the hydrograph of the Columbia River and adverse effects to eulachon larval and juvenile survival in the estuary, plume, and ocean, the Action Agencies should:**
    A. Monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile eulachon predators at representative locations in the estuary and plume.
    B. Monitor, and evaluate the causal mechanisms, e.g., shifts in the timing, magnitude, and duration of the hydrograph of the Columbia River, and migration/behavior characteristics affecting survival of larval eulachon during their first weeks in the plume-ocean environment.
    C. Monitor and evaluate the ecological importance of the tidal freshwater, estuary, plume, and nearshore ocean environments to the viability and recovery of the Columbia River subpopulation of eulachon.

2.19 Reinitiation of Consultation

This concludes formal consultation for ongoing operation and maintenance of the Columbia River System (CRS) and associated non-operational measures to offset adverse effects to listed species.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: 1) The amount or extent of incidental taking specified in the ITS is exceeded, 2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, 3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or 4) a new species is listed or critical habitat designated that may be affected by the action.

3. Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)]

This analysis is based, in part, on the EFH assessment conducted by NMFS and descriptions of EFH for Pacific Coast groundfish (Pacific Fishery Management Council [PFMC] 2005), coastal pelagic species (CPS) (PFMC 1998), Pacific Coast salmon (PFMC 2014); and highly migratory species (PFMC 2007) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce. In this case, NMFS concluded the proposed action would not adversely affect EFH for Pacific Coast groundfish, coastal pelagic species, and highly migratory species. Thus, consultation under the MSA is not required for these habitats.

3.1 Essential Fish Habitat Affected by the Project

The proposed action and action area for this consultation are described in the Introduction section to the biological opinion. The action area includes areas designated EFH for various life-history stages of two Pacific Coast salmon species: Chinook salmon and coho salmon (PFMC 2014). Habitat areas of particular concern (HAPC) within the action area include estuaries, complex channel and floodplain habitat, spawning habitat, and thermal refugia (PFMC 2005, 2014).

Freshwater EFH for Pacific Coast salmon (Chinook and coho) consists of four major components: 1) spawning and incubation, 2) juvenile rearing, 3) juvenile migration corridors, and 4) adult migration corridors and holding habitat, and overall, can include any habitat currently or historically occupied within Washington, Oregon, and Idaho. The important components of Pacific salmon marine EFH are: 1) estuarine rearing, 2) ocean rearing; and 3) juvenile and adult migration. The only marine EFH habitat found within the action area for this consultation is the estuarine rearing habitat in the lower Columbia River. Freshwater EFH found within the action area for this consultation includes all four components noted above for Chinook salmon and coho salmon. Detailed descriptions and identifications of EFH for salmon are found in Appendix A of Amendment 18 of the Pacific Coast Salmon Plan (PFMC 2014).

3.2 Adverse Effects on Essential Fish Habitat

As described in detail in the preceding opinion, the proposed action is expected to affect EFH components in the mainstem Snake and Columbia Rivers, and in the Lower Columbia River estuary. We conclude that the proposed action will have the following adverse effects on EFH designated for Chinook and coho salmon:

1. Reduction in habitat quality in the juvenile and adult migration corridors because operation of the dams and reservoirs causes the following: passage delays and increased freshwater travel times; increased stress, harm, and some mortality from having to navigate fish passage routes through the dams and reservoirs; reduced thermal refugia; exposure to elevated TDG; and increased predation.
2. Reduced access to mainstem spawning habitat for some ESUs of Chinook salmon due to presence and operation of the reservoirs.
3. Reduced quantity and quality of rearing habitat because of lost connectivity to the riverine and estuarine floodplain, reduced water quality, and reduced habitat complexity including thermal refugia habitat.

3.3 Essential Fish Habitat Conservation Recommendations

NMFS determined that the following conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the impact of the proposed action on EFH. All of the EFH conservation recommendations listed below are described in more detail in the proposed action (Section 1.3) and the ESA Terms and Conditions and Conservation Recommendations (found in the attached Incidental Take Statement, Section 2.17).

- Mainstem migration corridor habitat for adult Pacific Coast salmon will be improved through the following: Dworshak reservoir management and other augmented summer flow operations to improve water quality and increase water velocities, adult fish ladder temperature differential monitoring and management, adult fish ladder maintenance and passage improvements, daily monitoring of adult fish ladder passage conditions, in-season monitoring of adult ladder counts and adaptive management of spill program , project debris reduction and management improvements, adult fish trap improvements and juvenile bypass system (JBS) adult separator improvements at Lower Granite Dam, shad deterrence investigations at Lower Granite Dam, adhering to all fish passage plan and water management plan protocols and requirements for each project, evaluating the performance of adult fish passage structures, evaluating alternative transportation operations to increase adult returns to the Snake River, using alternative sampling methods and strategies for operation of the Northern Pikeminnow Management Plan (NPMP) (as opposed to boat electrofishing in Pacific Coast salmon migration habitat), and pinniped predation reduction and management efforts.

- Mainstem migration corridor habitat for juvenile Pacific Coast salmon will be improved through the following: the flexible spring spill and summer spill operations with adaptive management, augmented summer flow operations to improve water quality and increase water velocities (including Dworshak operations), John Day spring reservoir operations to deter Caspian tern nesting, the juvenile fish transportation and monitoring program, biological testing (and design/installation) of improved fish passage turbines, evaluation of the performance of fish passage structures including the evaluation of low juvenile survival at the Bonneville spillway, adhering to all fish passage plan and water management plan protocols and requirements for each project, implementation of the avian predation management plan, and implementation of the NPMP, including the Dam Angling Program, and including investigation into alternative sampling methods and strategies for operation of the NPMP.
- Spawning and incubation habitat quality and availability for Pacific Coast salmon will be improved at the reach scale through the full implementation of the Tributary Habitat Improvement and Effectiveness Monitoring Program.
- Quantity and quality of both freshwater and estuarine rearing habitat of Pacific Coast salmon will be improved through full implementation of the CEERP (Columbia Estuary Ecosystem Restoration Program) as well as the Tributary Habitat Improvement and Effectiveness Monitoring Program. Both programs will continue to improve water quality, and increase thermal refugia and habitat complexity. The CEERP will do so primarily by increasing estuarine floodplain connectivity.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, for Pacific Coast salmon.

3.4 Statutory Response Requirement

As required in section 305(b)(4)(B) of the MSA, the Action Agencies must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Action Agencies have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Action Agencies must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the Action Agencies. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The Action Agencies must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. Data Quality Act Documentation and Pre-Dissemination Review

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation. Other interested users could include the states of Oregon, Washington and Oregon, tribes, and others interested in the conservation of the affected ESUs/DPS. Individual copies of this opinion were provided to the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation. The document will be available through the NOAA Institutional Repository (https://repository.library.noaa.gov/), after approximately two weeks. The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

4.3.1 Standards

This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

4.3.2 Best Available Information

This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

4.3.3 Referencing

All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

4.3.4 Review Process

This consultation was drafted by NMFS staff with training in ESA and MSA implementation and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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Appendices to the 2020 Columbia River System Biological Opinion

Appendix A – Tributary Habitat Technical Foundation and Analytical Methods

Appendix B – Avian Predation Management

Appendix C – Life-cycle Model Outputs

Appendix A – Tributary Habitat Technical Foundation and Analytical Methods

A.1 Introduction

This appendix summarizes recent information on the scientific basis for understanding how tributary habitat actions can improve salmonid abundance, productivity, spatial structure, and diversity within the Columbia and Snake River basins. It also describes the methods and factors we considered in our analysis of the effects of tributary habitat improvement actions in this biological opinion (opinion). Finally, it discusses important considerations in implementation of tributary habitat improvement actions.

A.2 Scientific Basis for Tributary Habitat Improvement Actions

The National Marine Fisheries Service (NMFS) has determined, based on best available science, that by identifying the factors limiting habitat function, and by strategically implementing actions to alleviate those limiting factors, habitat function will improve and, ultimately, the abundance, productivity, spatial structure, and diversity of salmon and steelhead will improve as well. In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

The fundamental relationship between fish, freshwater habitat, and population response provides the basis for implementation of tributary habitat improvement actions, including those implemented under multiple Columbia River System (CRS) biological opinions. This relationship was articulated in Appendix C of the 2007 Comprehensive Analysis (USACE et al. 2007, Appendix C, Attachment C-1 and Annexes 1-3) and reiterated in NMFS' previous CRS biological opinions, including the 2008 biological opinion (NMFS 2008), its 2010 and 2014 supplements (NMFS 2010, 2014), and the 2019 biological opinion (NMFS 2019).[1] Below, we summarize and update the findings and discussion in those documents.

[1] In biological opinions before 2019, the CRS was referred to as the Federal Columbia River Power System, or FCRPS.

A.2.1 2014 Supplemental Biological Opinion

In the 2014 supplemental biological opinion, we described our knowledge of the basic relationships between fish and their tributary habitat, and the findings in the scientific literature about how changes in fish habitat affect fish populations. We evaluated multiple lines of evidence, including literature on the physical and biological effectiveness of improvement actions, correlation analyses, and preliminary results from monitoring in the Columbia River basin designed to evaluate the effects of various actions on tributary habitat limiting factors and on salmon and steelhead population response. We noted that the outcomes of habitat improvement are well documented and support our determination that the strategic implementation of actions to alleviate habitat-related limiting factors will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead.[2] We also noted that long-term studies were underway in the Columbia River basin to further validate and contribute to adaptive management and implementation of tributary habitat improvement actions (NMFS 2014).

We determined in the 2014 supplemental biological opinion that tributary habitat improvement actions have been well documented to provide benefits to fish at the stream-reach scale. We also noted that studies examining changes in salmon and steelhead survival at the population scale were less numerous, in part because directly measuring survival in response to habitat improvement at the watershed scale is complex, costly, and generally requires lengthy periods of action implementation and habitat and fish response monitoring. We found that available studies at the population or watershed scale supported our determination that tributary habitat improvements would lead to improved freshwater survival, as did correlation analyses that examined relationships between habitat improvement actions and fish abundance. We also determined that preliminary results from research, monitoring, and evaluation (RME)

[2] In the 2008 biological opinion and its 2010 and 2014 supplements, we characterized the benefits of tributary habitat improvement actions at the population level primarily in terms of their effect on freshwater survival, either life-stage-specific or total egg-to-smolt survival. We also assumed, based on best available information, that these improvements would carry on to direct improvements in recruits per spawner (R/S) and therefore contribute to achieving metrics, such as R/S > 1, that were used as one part of the analysis in those biological opinions. In the 2019 biological opinion and this current opinion, we characterize the effects of tributary habitat improvement actions at the population level primarily in terms of changes in population abundance, productivity, spatial structure, and diversity. We then qualitatively relate these population-level changes to effects to the species or designated critical habitat. This approach is consistent with our section 7 regulations, which direct NMFS to formulate the agency's biological opinion as to whether a proposed action is likely to: 1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or 2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species (50 CFR 402.02). The approach is also consistent with our longstanding use of "viable salmonid population" (VSP) parameters (McElhany et al. 2000) to evaluate Pacific salmon and steelhead population viability. The four VSP parameters (abundance, productivity, spatial structure, and diversity) encompass the species' "reproduction, numbers, or distribution," and are commonly used to evaluate long-term risk of extinction and population status relative to Endangered Species Act (ESA) recovery goals. All of these population parameters could affect survival and also mitigate extinction risk by making populations more resilient, and this is why we use these factors to assess the status of populations, which in turn informs the evaluation of species status.

implemented under the 2008 biological opinion appeared to support our determination (NMFS 2014).

In the 2014 supplemental biological opinion, we concluded that the best available scientific literature indicated that many habitat improvement actions (such as increasing instream flow, improving access to blocked habitat, reducing mortality from entrainment at water diversion screens, placing logs and other structures to improve stream structure, and restoring off-channel and floodplain habitat) can improve tributary habitat quantity and quality over relatively short time periods. We also concluded that for other habitat improvements, such as actions that address the source of fine sediment in spawning areas (e.g., road decommissioning) and the restoration of riparian vegetation, it may take decades to realize their full benefit (NMFS 2014).

In addition, we concluded that the best available scientific literature supports the approach of improving tributary habitat to increase survival of salmon and steelhead at the population scale, and we noted that preliminary results from tributary habitat RME conducted under the 2008 biological opinion provided evidence that the Action Agencies' habitat improvements were correctly targeting and improving degraded conditions and providing benefits to fish (NMFS 2014).

A.2.2 Updated Findings on Scientific Basis for Tributary Habitat Improvement Actions

Literature on fish habitat restoration is extensive and has been summarized recently in the context of salmon and steelhead recovery in the Columbia River basin (see Roni et al. 2002, 2008, 2014). More recently, Hillman et al. (2016) conducted a review of published and unpublished literature on the effectiveness of habitat improvements that built upon those earlier reviews. Pess and Jordan (2019) also summarized findings on habitat restoration actions at the site and reach scale. Roni (2018) reviewed studies that specifically examined fish movement in relation to river or floodplain habitat restoration or improvement. Haskell et al. (2019) and Bennett et al. (2016) summarized key findings from 16 intensively monitored watersheds (IMWs) and evaluated IMWs as a method for evaluating the effects of tributary habitat improvement actions, and the Bureau of Reclamation recently completed a report summarizing RME results in the Methow River basin (BOR 2019). In addition, the Independent Scientific Advisory Board (ISAB 2015) evaluated density dependence (the relationship between population density and population growth rate) in the Columbia River basin, including density dependence in tributary habitats, and evaluated research and recovery efforts for Upper Columbia River spring-run Chinook salmon, including questions related to the prioritization and effectiveness of habitat improvement actions for that evolutionarily significant unit (ESU) (ISAB 2018). Below, we briefly describe results from recently published literature and from monitoring and evaluation conducted in conjunction with CRS tributary habitat actions, and present our conclusions regarding how that information supports the basis of the CRS tributary habitat improvement actions.[3]

A.2.2.1 Response at the Stream-Reach Scale

Hillman et al. (2016) searched for literature not reviewed in the earlier efforts by Roni et al. (2002, 2008, 2014) and identified papers that provided quantitative information on physical and biological response to habitat improvement. They provided an annotated bibliography for each paper they reviewed, summarizing key findings and reporting quantitative changes in physical and biological parameters, including changes in fish habitat and fish abundance where available. They summarized the results for major categories and subcategories of improvement actions. Below, we summarize these findings with extreme brevity and provide a few anecdotal examples from recent monitoring for illustrative purposes; readers are referred to Hillman et al. (2016), Pess and Jordan (2019), Roni et al. (2002, 2008, 2014, 2018), and specific monitoring reports and publications for more detail.

Barrier removal: Habitat conditions have been shown to respond quickly to barrier removal, and positive effects are usually long term or even permanent. Reviews of the effectiveness of habitat improvements have consistently reported removal of barriers or installation of fish passage as one of the most effective methods for increasing fish numbers (Roni et al. 2014, Hillman et al. 2016, Pess and Jordan 2019). Examples abound, and we include just a few here for illustration:

- In many years, low flows and obstructions blocked Loup Loup Creek, the southernmost tributary of the Okanogan River, making it impassable to fish trying to reach habitat in the creek's upper reaches. Agreements on water use, removal of culverts, and alteration of another barrier to improve fish passage reopened the creek in 2010. Increasing numbers of juvenile steelhead have been documented by annual snorkel surveys in the creek, and adult steelhead are also returning, with an average of 22 adult steelhead returning to the creek each year from 2012 to 2016 (OBMEP 2018).

[3] Under the 2008 biological opinion and the Adaptive Management Implementation Plan (adopted as part of the 2008 biological opinion and its 2010 supplement), the Action Agencies implemented an extensive tributary habitat monitoring program (under Reasonable and Prudent Alternative (RPA) Actions 56 and 57), paired with fish population status monitoring (under RPA Action 50), to define the benefits of habitat improvements (NMFS 2008, 2010, 2014). This RME program was part of an adaptive management approach designed to inform and shape future habitat actions so they deliver increasingly meaningful and cost-effective results (BPA and BOR 2013). The program was described briefly in the 2014 supplemental biological opinion (and in more detail in BPA et al. [2013], BPA [2013], and BPA and BOR [2013]). Hillman et al. (2016), Bennett et al. (2016), and Haskell et al. (2019) incorporated recent results from that RME program. The Action Agencies continued an RME program, although at a reduced level, under the 2019 biological opinion (NMFS 2019), and they propose to continue, under their 2020 proposed action (BPA et al. 2020, USACE 2020), to implement a tributary RME program and to engage in a collaborative process to develop and implement a Columbia River basin tributary habitat RME strategy.

- Evaluations of culvert removal projects in Washington State, including two sites in the Columbia River basin, have indicated increases in juvenile coho salmon numbers within 2 years of culvert removal or replacement (O'Neal et al. 2016).
- In an evaluation of fish numbers above and below former impassable culverts at 32 sites in the interior Columbia River basin, no differences were detected in numbers of steelhead or other salmonids above and below the formerly impassable barriers (Hillman et al. 2016). This suggests that culvert replacement has been effective in allowing juvenile salmonids access to formerly blocked habitat.

Instream structures: Actions to improve stream complexity include the placement of structures such as logs, logjams, cover structures, and boulders, and the addition of gravel. Most published literature on placement of instream structures is related to placement of large wood, and the vast majority of these studies show a positive response for habitat and salmonid fishes (Hillman et al. 2016, Pess and Jordan 2019). The increase in fish abundance in improved habitats was typically related to an increase in habitat capacity, and not due to a redistribution of fish from other habitats of the same stream reach (Polivka et al. 2015, Roni 2018). The lack of response or small decrease in abundance reported in some studies appears to be largely because watershed processes (e.g., sediment, water quality, etc.) were not addressed, because monitoring had not occurred long enough to show results, or because treatments had resulted in little change in physical habitat. Although more research specific to these action types for Chinook salmon and steelhead in the Columbia River basin is needed, available studies show that the effects of instream structures are generally rapid (1 to 3 years), often occurring during the first high-flow event (Hillman et al. 2016).

Several studies (Clark et al. 2017, 2019) evaluated projects throughout the Columbia River basin that involved adding large wood to streams. The evaluations included snorkel surveys to examine fish numbers in sites where debris had been added as part of restoration, compared to numbers from surveys at control sites where no improvements had been made. Clark et al. (2017) found nearly double the density of juvenile steelhead in streams with wood structures compared to those without. The improvement in fish numbers was consistent among various sites and watersheds. In addition, the restored reaches included more pools and larger pools, signaling that the woody debris helps add needed complexity to rivers and streams by altering river flows that shape and scour the streambeds. Clark et al. (2019) found that the proportion of pool area and the amount of pools, large wood, and pool-forming large wood were significantly higher in treated reaches than in control reaches. Juvenile Chinook salmon, coho salmon, and steelhead abundances were also significantly higher in treated reaches than in control reaches.

In three tributaries of Asotin Creek, a tributary of the Snake River in southeast Washington, from 2012 to 2016, scientists installed more than 650 log structures made of wood debris held in place by log piles driven into the stream bottom in an effort to add complexity to the stream and provide habitat for fish. Early monitoring documented a 28.8 percent increase in juvenile steelhead abundance in areas with the wood debris compared to those without, and modeling suggests that the carrying capacity of the streams has increased by 50 percent following addition of the debris. Initial results also suggest that the productivity of fish populations may be increasing, as reflected by the number of surviving smolts per female spawning in the research stretches of streams. Researchers will continue tracking the number of smolts per female to determine whether the increases continue in the long term (Griswold and Phillips 2018).

One relatively new type of instream habitat improvement with promising results is the addition of structures to mimic the hydro-geomorphic effects of beaver dams. The importance of beaver dams for creating habitat is well documented. "Beaver support structures" or "beaver dam analogs" can have similar effects on stream velocity, surface water level and routes, ground water level, sediment sorting, water table, and riparian vegetation. Results from one such project in Bridge Creek, in the John Day River basin, have shown that beaver dam analogs can lead to aggradation of incised channels, increased side channels, increased floodplain area, and increased groundwater levels, as well as to construction of actual beaver dams (Pollock et al. 2012, DeVries et al. 2012, Bouwes et al. 2016b). Results from this study in Bridge Creek also show significant increases in the density, survival, and production of steelhead following construction of beaver dam analogs (Bouwes et al. 2016b). Studies outside the Columbia River basin suggest that instream structures can help to restore human-impacted river ecosystems, primarily through altering the abundance and biomass of consumers and resources in the food web (Thompson et al. 2017).

Floodplain habitat reconnection: Studies on the effectiveness of floodplain habitat reconnection have consistently shown rapid recolonization of newly accessible habitat by salmonids and other fishes, and fish rearing in such habitats can have higher growth rates than those rearing in the mainstem. Success of these projects depends on their connection with the main channel and their morphology and depth, as well as on addressing water quality and other upstream problems, although more monitoring of such projects in the Columbia River basin is needed (Hillman et al. 2016). Examples with positive results include remediation and reconnection of former mining dredge ponds to the Yankee Fork of the Salmon River in central Idaho, where the reconnected habitats quickly became home to juvenile salmon and spawning steelhead (Bellmore et al. 2012). Also, improvements coordinated by the Confederated Tribes of the Umatilla Indian Reservation on Catherine Creek in northeast Oregon increased the habitat capacity for juvenile salmon by roughly two to eight times in terms of usable area for fish, depending on the time of year. Biologists recorded immediate improvements in favorable habitat measures, such as the frequency of slow-water pools and the amount of large woody debris (CTUIR 2017). The floodplain of the upper Chilliwack River watershed, a tributary to the Fraser River in British Columbia, was extensively restored from 1996 to 2000 through off-channel habitat restoration. Researchers estimated that 27 to 34 percent of the total production of out-migrating coho salmon smolts in the watershed could be attributed to the newly created habitat (Ogston et al. 2014). Floodplain reconnections can also improve hyporheic flow and the ecosystem processes that allow restoration of habitat and water quality to occur. Singh et al. (2018) showed that levee setbacks in a reach of the Yakima River improved the hyporheic connection between surface and groundwater in the Yakima floodplain, which demonstrates that levee setback can provide a valuable hydrologic tool to restore ecosystem processes in previously leveed rivers.

Modeling efforts for the Columbia River basin suggest that there has been an estimated 26 percent decrease basinwide in floodplain channel area from historical conditions, and that reconnecting historical floodplains currently used for agriculture could increase side-channel habitat by 25 percent and spring Chinook salmon parr rearing capacity by 9 percent over current estimates (Bond et al. 2019). While individual watersheds throughout the Columbia River basin vary greatly in habitat factors that limit salmon recovery, large-scale estimates of restoration potential like this one are useful in making decisions about long-term restoration goals (Bond et al. 2019).

Riparian planting: Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, improved bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014, Hillman et al. 2016, NMFS 2017b). While some benefits of riparian planting begin to accrue after 10 to 15 years (Justice et al. 2017, Pess and Jordan 2019), the full effects of riparian plantings on habitat conditions can take more than 50 years to accrue, in part because of the long lag time between tree growth and any change in channel conditions, delivery of large wood, and shading effects on temperature. As a result, few studies have examined the response of instream habitat or fish to riparian planting or thinning. One retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and fish habitat at enhanced sites. Riparian enhancement actions are also often critical for success of other enhancement actions (e.g., floodplain, instream) (Hillman et al. 2016). Justice et al. (2017) found through modeling that a combination of riparian restoration and channel narrowing could both reduce stream temperatures and increase the abundance of Chinook salmon parr in the Upper Grande Ronde River and Catherine Creek in northeast Oregon. They utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River and Catherine Creek basins, and concluded that restoration of such streams could more than make up for an expected increase in summer stream temperature through 2080.

Livestock exclusions: Monitoring of livestock exclusions to improve riparian areas shows that habitat response can occur relatively rapidly (<5 years), but studies of fish response have been variable. Lack of fish response has been attributed to short duration of monitoring, small size of exclosures, and the influence of upstream processes (Hillman et al. 2016). In one example, researchers are tracking the condition of seven livestock exclusion projects across the Columbia River basin, although only two of the sites include observations from before the livestock exclusion projects for comparison. Where data are available, comparisons show a reduction in erosion and a slight increase in canopy cover, which matches broader findings on the relationship between grazing and riparian health. In a study of 261 grazed and ungrazed watersheds, those without grazing impacts demonstrated more stable banks, deeper pools, and reduced amounts of fine sediment. Researchers expect to see continued improvements in riparian conditions in areas where grazing impacts have been controlled, although the full response may take several years (O'Neal et al. 2017).

Reduction of excess fine sediment: Reduction of excess fine sediment is usually accomplished through road enhancement, agricultural treatments, and riparian enhancement. Actions such as road decommissioning, removal, and upgrading are successful in decreasing fine sediment delivery to streams. Little monitoring and evaluation has been done to examine the response of fish or other biota to road treatments (Hillman et al. 2016).

Flow augmentation: Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017b). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Hillman et al. 2016). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and illustrate the success of these projects (Roni et al. 2008). For example, ongoing studies in the Lemhi River basin show increased spawner and juvenile fish numbers following enhancement of instream flows in tributaries (Uthe et al. 2017, Appendix A of Griswold and Phillips 2018). Similarly, re-watering a previously dewatered reach of the Bridge River in British Columbia led to increases in juvenile Pacific salmon and riparian plant growth following enhancement of instream flows (Hall et al. 2011; Bradford et al. 2011, cited in Hillman et al. 2016). The effects of flow augmentation on habitat conditions depend on the amount of flow within the channel, how much water is added, and how long it remains in the stream (e.g., is the water removed downstream? is the augmentation perpetual or for a limited time of year or number of years?). Augmented flow in dewatered channels or in streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).

Nutrient enhancement: Hillman et al. (2016) did a comprehensive review of literature on the topic of nutrient enhancement. They concluded that while additional study is needed, available studies suggest that nutrient enrichment through the addition of inorganic nutrients, salmon carcasses, or an increase in spawning fish can increase primary and secondary production and fish growth and, possibly, survival of salmonids in oligotrophic streams.

Acquisition and protection: Protection of high-quality riparian/floodplain habitat (e.g., through conservation easements and acquisitions) helps to maintain riparian vegetation, reduce delivery of sediments and pollutants to streams, and maintain bank stability and water quality. The most favorable responses come from protecting large areas of streamside habitat in perpetuity, addressing upstream processes that negatively affect downstream habitat conditions, and regulating/managing activities within the protected areas (Hillman et al. 2016).

A.2.2.1.1 Summary: Response at the Stream-Reach Scale

Extensive literature continues to document benefits to habitat and fish at the stream-reach scale as a result of habitat improvements. Barrier removal and the placement of large woody debris and other types of instream structures are known to improve instream habitat and increase numbers of trout and juvenile coho salmon and steelhead. Various floodplain habitat improvement and enhancement techniques also show positive responses.

Relatively little work has been done to examine the physical and biological response in streams from riparian planting, flow augmentation, sediment reduction (road removal), or acquisition and protection. Additional monitoring or focused studies examining the effects of these methods, and their cost-effectiveness, would be beneficial. Additional studies of instream structures and floodplain reconnection specific to Chinook salmon in the Columbia River basin may also be warranted; many studies of those techniques have been done in coastal coho streams, but the existing body of literature provides confidence in the effects of those actions.

Addition of inorganic or organic nutrients or salmon carcasses has been shown to increase primary and secondary production and fish growth, although few studies have documented increased fish numbers. Moreover, studies to date in the Columbia River basin have not shown an increase in fish numbers. Thus, these techniques should still be considered experimental and in need of additional evaluation.

In studies where no response to habitat improvement actions has been shown, it appears to be largely because watershed processes (e.g., sediment, water quality, etc.) were not also addressed, because monitoring had not occurred for long enough to show results, or because treatments had resulted in little change in physical habitat (Hillman et al. 2016). These findings highlight factors important to the success of habitat improvement actions: ensuring that upstream and watershed processes (such as sediment and water quality) have been addressed, understanding what factors are limiting fish production, and ensuring that the total amount or extent of treatment is adequate.

Roni (2018) reviewed literature that informed a key uncertainty about the effects of tributary habitat improvement: whether fish concentrate around restoration projects (i.e., whether fish move into restored habitat but without an increase in their total abundance) or whether restoration actually increases total abundance. Based on his review, he concluded that existing literature provides little evidence to support the view that river restoration leads to concentration of fish at restoration sites. Instead, he found that the literature does suggest that restoration may lead to increased survival, increased abundance, or both. Roni (2018) notes that the scientific literature suggests that fish response to restoration varies greatly depending on the watershed template, location and characteristics of the habitat restoration, and the life history and limiting factors for the species being addressed.

A.2.2.2 Response at the Population/Watershed Scale

Population- or watershed-scale monitoring projects are rare compared to reach-scale monitoring, because population-scale monitoring is challenging and costly, requiring robust large-scale monitoring and implementation designs; long-term monitoring, coordination, and funding commitments; and large and extensive treatments. However, a number of IMWs have been established throughout the Columbia River basin and the Pacific Northwest.

IMWs are large-scale experiments with well-developed, long-term monitoring designed to determine population/watershed-scale fish and habitat responses to enhancement actions. Although most IMWs would not be expected to show full results yet, a few have demonstrated fish responses at the watershed scale. Ten have detected improvements in juvenile fish metrics, and four have documented significant increases in adult salmon abundance. Adult increases were demonstrated primarily in IMWs that included removals of dams or barriers that opened new areas for colonization. Some IMWs have shown little or no response even after intense treatment and monitoring (e.g., Tenmile and Fish Creeks). This is believed to be because broader watershed-scale factors, such as floods and road failures, limited the success of the restoration actions implemented, or, in some cases, because design and procedural issues during monitoring limited the ability of the IMW to detect responses to enhancement.

Below, we highlight notable results from some of the longer-running IMWs in the Columbia River basin. Because enhancement actions have generally not been implemented for a long enough period for habitat and fish populations to respond and to allow full evaluation, most IMWs are several years away from definitive conclusions regarding enhancement effectiveness. Several summaries of results to date have been completed (Roni et al. 2014; Hillman et al. 2016, 2019; Bennett et al. 2016; Griswold and Phillips 2018; Haskell et al. 2019), and readers are referred to those summaries, as well as to publications cited therein and below regarding specific IMWs for additional detail.

Asotin Creek IMW: The goal of the Asotin Creek IMW is to test the effectiveness of adding large wood to increase habitat complexity and steelhead production. Researchers added large wood to treatment sections and compared the treated sections to control sections. Although monitoring is still ongoing, initial results show significant improvements in habitat complexity. The frequency of large wood has increased by 185 percent in treated sections compared to control sections, and the structures are creating hydraulic and geomorphic responses. It is too early to evaluate changes in steelhead production, but researchers have documented a significant (250 percent) increase in juvenile abundance in treatment reaches compared to control reaches. Practitioners also report increases in juvenile growth, survival, and productivity, as well as in numbers of adults and redds (Haskell et al. 2019). The remainder of the study will focus on estimating changes in productivity and other life-history characteristics of steelhead, and identifying the causal mechanisms of changes (Bouwes et al. 2016a).

Bridge Creek IMW: The Bridge Creek IMW is designed to test whether constructing beaver dam analogs to encourage natural beaver dam development can improve habitat in Bridge Creek, a deeply incised stream in the John Day River basin that has limited riparian vegetation and poor habitat complexity and quality. The hypothesis is that the analogs and beavers will aggrade the channel and thereby alter hydrology, temperature, geomorphology, and vegetation to improve habitat conditions for steelhead. Researchers saturated four reaches on Bridge Creek with beaver dam analogs and identified control reaches. Monitoring occurred three years before treatment (2007 to 2009) and four years after treatment (2010 to 2013). In 2013, researchers counted 236 beaver dams in Bridge Creek. About half of these were made by beavers; the others were functioning beaver dam analogs (overall an eight-fold increase over the pre-treatment conditions). Treated reaches had higher water levels and deeper pools, lower water temperatures, large upstream dam pools and downstream plunge pools, and large increases in inundation area, thermal refugia, and side channels. The beaver complexes also created greater variability in water depths, channel widths, and temperatures, indicating an increase in habitat complexity. These changes translated into changes in fish density, density-dependent decreases in growth, and increases in juvenile survival. Four years following treatment, juvenile production had increased in Bridge Creek by 175 percent relative to the control. The treatments had no negative effects on upstream or downstream migration of juvenile or adult steelhead (ISEMP/CHaMP 2015, 2016; Bouwes et al. 2016b).

Entiat River IMW: Researchers and stakeholders determined that reduced instream complexity was the primary concern limiting Chinook salmon and steelhead production in the lower 26 miles of the Entiat River. Current land uses (primarily agriculture, roads, and residential development) restrict habitat improvement options in this portion of the river, so an engineered approach is being used to increase complexity, including adding rocks and large wood to the river, and reconnecting the floodplain by breaching levees where possible. After completion of two of four planned rounds of habitat actions, affecting about 14 percent of the targeted stretch of river, habitat monitoring showed a significant increase in the volume of wood in the Entiat River (ISEMP/CHaMP 2015, 2016), and fish were using treated areas on a seasonal basis at a fine scale (R.D. Nelle, U.S. Fish and Wildlife Service, personal communication, cited in Hillman et al. 2016). Polivka et al. (2015) also found that both Chinook salmon and steelhead were more abundant in improved pools than in untreated pools in early summer, but this difference was mostly absent by September. Polivka and Claeson (2020) surveyed reaches of the Entiat River treated with engineered logjams and reaches without treatments to determine if restoration had increased habitat capacity. They found that the density of juvenile Chinook salmon and steelhead was 3.1 and 2.7 times greater, respectively, in treated habitat compared to untreated habitat. To distinguish whether these density differences were actual increases in capacity rather than fish moving from poor habitat to good habitat, they compared density in unrestored habitat in both treated and untreated reaches. They found no differences for either species, confirming that the increased density in restored habitat units did not come from depletion of unrestored habitat in the same reach. Thus, they concluded that the restoration had increased the habitat capacity of the reach at the scale of pools created by engineered logjams.

The Entiat River has not yet experienced the high post-treatment flows needed to affect channel morphology as hypothesized. Furthermore, the enhancement plan is not yet complete. Whether the enhancement plan can be implemented as originally designed is questionable because landowner constraints currently limit the completion of the implementation plan. The Entiat IMW illustrates many of the challenges of implementing enhancement actions under a structured monitoring design (Hillman et al. 2016).

Lemhi River IMW: In the Lemhi River, stakeholders and researchers determined that insufficient instream flow, loss of access to historically important habitat, and simplification of mainstem habitat were the primary ecological concerns for Chinook salmon and steelhead productivity (ISEMP/CHaMP 2015, 2016). Researchers developed a plan to remove or reduce migration barriers, maintain or enhance riparian conditions, decrease fine sediment and temperatures, increase tributary connections, and improve habitat quality. Twenty-two types of habitat improvement actions were planned in high-priority watersheds. Tributary water diversions have been replaced with mainstem diversions, allowing tributaries to be reconnected to the mainstem, reducing total water withdrawals, and allowing cooler tributary water to enter the mainstem Lemhi River. In addition, tributary passage conditions have been improved, providing access to relatively intact public lands. Fish and habitat monitoring are underway to detect life-stage-specific responses to individual habitat actions and the accumulated effects of multiple actions at the population scale.

The reconnection of tributaries to the Lemhi River nearly doubled the length of stream available to Chinook salmon and steelhead (ISEMP/CHaMP 2016). Minimum instream flow agreements have addressed passage impediments and reduced temperatures in the upper mainstem Lemhi River. Overall, restoration has resulted in a 22 percent increase in wetted stream area and a 19 percent increase in pool habitat compared to pre-treatment conditions. Adult steelhead have moved into each of the five reconnected tributaries, and these tributaries are producing anadromous juveniles. Researchers have also documented the presence of adult Chinook salmon in two of the five reconnected tributaries, and juvenile Chinook salmon in all reconnected tributaries (Hillman et al. 2016, Haskell et al. 2019). This is the first occurrence of juvenile salmon in four of the five tributaries since the mid-2000s. The IMW team has reported an increase in juvenile Chinook salmon productivity (Uthe et al. 2017, Haskell et al. 2019). Overall, work in the Lemhi River basin has increased the summer rearing capacity for parr by 62 percent. Monitoring information and modeling results now indicate that juvenile Chinook salmon rearing habitat, particularly winter habitat, is currently limiting in the lower Lemhi River. As a result, habitat improvement efforts have shifted to improve habitat in the lower Lemhi River (Hillman et al. 2016).

Fish Creek IMW: Fish Creek, a tributary to the Clackamas River in Oregon, was one of the earliest IMWs. The goals of enhancement were to increase the amount of pool habitat for summer and winter rearing and the amount of habitat for anadromous salmonids (Chinook and coho salmon and steelhead). Intensive monitoring of enhancement activities began in 1982 and continued through 1995. Some preliminary enhancement activities occurred in 1983, but most work (large wood placement, off-channel pond construction) occurred from 1986 to 1988. This included placement of 500 large wood structures covering much of the anadromous zone of Fish Creek. Despite intensive monitoring of habitat and numbers of parr, smolts, and adults, significant changes in fish numbers were not detected after enhancement. There were rapid increases in pool habitat following placement of instream structures, but no significant increases in coho salmon or steelhead parr or smolts were detected. Chinook salmon were present only during the initial years of the study, and their response to enhancement could not be examined.

Floods in the winter of 1995 to 1996 damaged or destroyed many of the instream structures, and road failures and other broader watershed-scale factors and processes following enhancement appear to have limited the success of the habitat actions. These results highlighted the need for 1) addressing watershed-scale processes, 2) having a control watershed, and 3) not relying solely on statistical significance to determine fish response to enhancement (Reeves et al. 1997, cited in Hillman et al. 2016).

Methow River IMW: In the Methow River basin, analysis indicated that insufficient instream flows, floodplain connectivity, and off-channel habitat; fish passage barriers; high levels of fine sediments; and degraded riparian conditions limited salmonid productivity. As a result, more than 120 improvement and protection projects have been implemented within the basin since 1999. Actions include augmenting flow, screening of water withdrawals, improving fish passage, reconnecting floodplains and side channels, improving riparian habitat, and placing of instream structures. A collection of studies designed to examine different reach-scale enhancement measures and limiting factors was carried out (see, e.g., Bellmore et al. [2013], Benjamin and Bellmore [2016], Bellmore et al. [2017], and Martens and Connolly [2014]). Results were summarized in a report by the Bureau of Reclamation (BOR 2019) and include the following:

- Chinook salmon and steelhead out-migrant abundances showed high variability across years. Spring Chinook salmon out-migrant abundances appeared to be trending upward over time, but steelhead did not show a strong trend. Egg-to-smolt survival increased for spring Chinook in the Twisp River (BOR 2019).
- Increasing the hydrologic connectivity between off-channel habitat and the mainstem increased use by target species (BOR 2019).
- A greater percentage of invertebrate food sources were consumed by salmonids in side channels compared to the main channel. Increasing connectivity may increase fish production because of the abundant food resources frequently found in side channels (BOR 2019).
- Hyporheic upwelling moderates surface-water temperatures and can increase fish production. Placing side channels in areas likely to receive upwelling, such as the inside of a meander bend, has been shown to increase groundwater connectivity (BOR 2019).
- Side-channel enhancement projects with sufficiently deep pools and large wood improved habitat suitability and carrying capacity. Chinook salmon and steelhead carrying capacity of reconnected side channels was 251 percent higher, on average, than in the main channel (based on food availability) (Bellmore et al. 2013), and densities (but not survival) increased for both Chinook salmon and steelhead following habitat action implementation. The side channels also provide escape cover for juvenile Chinook salmon and steelhead from predatory fish species (Haskell et al. 2019). Target species densities in the mainstem and side-channels of the Methow River were positively associated with deep pools with large wood and overhead cover (BOR 2019).

- On the Entiat River, early-summer rearing density of juvenile Chinook and steelhead was approximately doubled at placed large wood structures compared to untreated areas (BOR 2019).
- Channel reconstruction and large wood enhancement in a small stream can increase spawning densities, total fish production, and the consumption of invertebrate food resources (BOR 2019).

Potlatch Creek IMW: In the Potlatch Creek basin, research indicated that low flows and dewatering were the primary factors affecting steelhead production in the lower basin, while a lack of habitat complexity was limiting steelhead production in the upper basin (Bowersox and Biggs 2012, Heekin 2013). In the lower basin (Big Bear Creek), low flows and dewatering are being addressed by removing fish passage barriers to open inaccessible habitat and developing water-release strategies from headwater reservoirs. In the upper basin (East Fork Potlatch River), habitat enhancement actions, including woody debris treatments and meadow rehabilitation, are being implemented to improve habitat complexity. After about 25 percent of planned treatments had been completed, preliminary results suggest that juvenile steelhead densities were greater within treatment reaches than in control reaches in the upper basin, and steelhead redds had been found above the site of the Dutch Flat Dam removal in the lower watershed. These and other fish and habitat responses indicate the potential for future population-level responses (Uthe et al. 2017, Haskell et al. 2019).

Wind River IMW: In the Wind River basin, researchers and stakeholders identified impaired fish passage, reduced abundance of instream woody debris, increased sedimentation and scour, and reduced channel stability and habitat complexity as the primary concerns limiting Chinook salmon and steelhead production (Coffin 2014, Buehrens and Cochran 2015). A collaborative enhancement and monitoring program initiated in the 1990s included the removal of Hemlock Dam on Trout Creek in 2009 and Martha Creek Dam in 2012, as well as the decommissioning of roads, addition of woody debris, removal of invasive plant species, enhancement of riparian areas, and improvement of fish passage at road crossings. Increases in steelhead adults and smolt density have been documented in Trout Creek (treated watershed) relative to the Wind River (untreated, reference watershed). For example, adult returns increased from 77 spawners in Trout Creek (pre-treatment) to 208 spawners in 2017 (after treatment), and smolt density increased 29 percent in Trout Creek (treatment site), while in the Wind River (reference site) it decreased 7.4 percent (Haskell et al. 2019).

A.2.2.2.1 Summary: Response at Population/Watershed Scale

Although the population/watershed-scale effectiveness monitoring projects are in varying stages of completeness, some are demonstrating habitat and fish responses. The most immediate responses have occurred where barriers were removed, resulting in increased spawning distributions of salmon and steelhead and increased juvenile life-history diversity. Projects that improved floodplain and side-channel connectivity have also shown significant benefits. For example, the use of beaver dam analogs and beavers to reconnect floodplain habitat and reduce channel incision have shown large improvements in juvenile steelhead abundance, survival, and production. Reconnecting side channels in the Methow River basin increased habitat area and fish capacity within treated reaches. Instream placement of large wood has, in general, increased habitat diversity by increasing pools and side channels, which has resulted in an increase in juvenile fish density and survival and, in some cases, reduced fish growth. At this time, nutrient enhancement has not been fully evaluated.

Researchers have noted both the utility and limitations of IMWs for evaluating population and watershed-scale responses (Bennett et al. 2016, Griswold and Phillips 2018, Haskell et al. 2019), and have concluded that successful IMWs appear to have the following characteristics: 1) implementers conduct watershed assessments and/or use modeling to identify problems and limiting factors (ecological concerns) within the watersheds before developing an enhancement plan; 2) implementers work with stakeholders and landowners to prioritize and sequence appropriate enhancement actions; 3) implementers use robust experimental designs and implement enhancement and monitoring plans within an adaptive management framework; 4) a large percentage of the watershed is improved; 5) projects are set up to identify causal mechanisms; 6) there is a commitment to long-term monitoring and funding (>10 years); and 7) enhancement, monitoring, funding, and implementation entities are well coordinated (Hillman et al. 2016). Factors that continue to make implementing IMWs a challenge include: lack of ability to control other management activities, coordination of enhancement activities and monitoring across multiple organizations, and funding (Roni et al. 2015). Excellent coordination among the various entities and stakeholders is needed to help maintain suitable control streams. Several authors of recent retrospective reports have highlighted the importance of coordination and communication between restoration action implementation programs and monitoring programs to ensure the proper placement and design of actions, as well as the potential of detecting results (Bennett et al. 2016, Hillman et al. 2016, Haskell et al. 2019). The majority of the region's IMWs have documented positive results from habitat implementation actions to either habitat parameters, fish parameters, or both. Some IMWs have not documented conclusive results, but this is due in large part to the long time periods necessary to affect habitat change and subsequent fish response (Haskell et al. 2019)

Finally, as noted by Chapman (1996), Reeves et al. (1997), and others (cited in Hillman et al. 2016), maintaining control streams is an important element of IMWs. Finding control streams is difficult, and there is no guarantee that control streams will remain suitable throughout the life of the project.

A.2.2.3 Density Dependence

The productivity of fish populations is density dependent, meaning that the productivity of a population declines as the density of fish in a habitat increases.[4] The productivity of a population

[4] Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population productivity over an entire life cycle. The indicator for productivity is the average number of surviving offspring per parent, which can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

will be lowest when a particular habitat is at capacity. At this point, further increases in abundance will not result in higher productivity (i.e., in more fish surviving to the next life stage), and in some cases increased abundance at this point could result in declines in productivity. For example, in freshwater habitats, as the density of smolts increases, increased competition for limited resources (e.g., food and shelter) drives survival down (or drives movement of fish to different habitats if available). In addition to a population being limited by the quantity or quality of a particular type of habitat (e.g., juvenile rearing habitat), the spatial patterns of habitat may also be limiting. Spawning and rearing habitat need to be in close enough proximity to each other for the fish to utilize them (Falke et al 2013).

The ISAB examined the question of density dependence and determined that "density effects on smolt production are now strongly evident at spawning abundances that are low relative to historical levels, implying that existing freshwater habitat is constraining the maximum sustainable size of the population" (ISAB 2015). The ISAB noted that dams and other development had limited fish to two-thirds of their historical habitat, and much of the habitat they could reach was degraded and could not support as many fish as it once did. The evidence of density dependence "suggests that habitat capacity has been greatly diminished," the ISAB concluded (ISAB 2015). The loss of habitat, "continuing changes to environmental conditions stemming from climate change, chemicals, and intensified land use appear to have further diminished the capacity of habitat that remains accessible" (ISAB 2015). The ISAB found that "the overall implication is that total adult returns of naturally spawning and hatchery fish may now be exceeding the carrying capacity of some areas of the Columbia Basin and its estuary" (ISAB 2015). In this case, improvements in tributary habitat capacity or productivity, if targeted at limiting life stage and limiting factors, would be likely to improve overall population abundance and productivity by removing a bottleneck on population growth.

A.2.2.4 Climate Resilience and Tributary Habitat Actions

Climate change is expected to adversely affect tributary habitat conditions for Columbia River basin salmon and steelhead (Climate Impacts Group 2004, Scheuerell and Williams 2005, Zabel et al. 2006, ISAB 2007). Likely changes have been characterized generally by the ISAB as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow being stored until the spring/summer melt season.
- Lower snowpack will mean that watershed runoff decreases earlier in the season, resulting in lower stream flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures will rise, especially during the summer months, when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the Pacific Northwest. Effects are difficult to predict, and some species are expected to be more vulnerable than others (Crozier et al. 2008, 2019, Waples et al. 2009, Lynch et al. 2016). Stream temperatures are expected to increase in most rivers, but the effect is expected to be greater where temperatures are already near the lethal or sub-lethal thresholds for salmon and steelhead, and lower in rivers where current temperatures are well below these thresholds (Beechie et al. 2013). Some rivers are expected to see large increases in peak flows, whereas others are expected to experience decreased low flows (Arnell 1999, Mantua et al. 2010). River flow is already becoming more variable in many rivers and is believed to negatively affect anadromous fish survival (Ward et al. 2015). Changes in stream temperature and flow regimes are also likely to lead to shifts in the distributions of native species and facilitate establishment of exotic species, affecting species interactions and predator-prey relationships (Lynch et al. 2016, Rehage and Blanchard 2016). How all these changes will affect freshwater ecosystems will depend on their specific characteristics and location (Crozier et al. 2008, Martins et al. 2012).

There has been some debate about the extent to which habitat restoration can compensate for anticipated shifts in temperature and hydrology. However, Beechie et al. (2013) concluded that past land and water uses have often degraded habitats to a greater degree than that predicted from climate change alone, presenting substantial opportunities to improve salmon habitats more than enough to compensate for expected climate change effects over the next several decades. Justice et al. (2017) demonstrated through modeling that a combination of riparian restoration and channel narrowing could reduce stream temperatures and increase the abundance of Chinook salmon parr in the Upper Grande Ronde River and Catherine Creek in northeast Oregon. They concluded that restoration of such streams could more than compensate for an expected increase in summer stream temperature through 2080. Crozier et al. (2019) looked at methods of increasing climate resilience for Pacific salmon and steelhead and concluded that reducing any anthropogenic stressor could improve response to climate change by improving the overall status of an ESU or distinct population segment (DPS) (in terms of abundance, productivity, spatial structure, and diversity) and thereby making the ESU or DPS more resilient and less vulnerable to stochastic extinction.

Beechie et al. (2013) reviewed pertinent literature to evaluate whether specific restoration action types would likely ameliorate climate change effects on flood flows, low flows, or stream temperature. They grouped restoration actions on the basis of the watershed processes or functions they attempt to restore and classified them as either likely or not likely to ameliorate a climate change effect on high stream flows, low stream flows, and stream temperature. They also reviewed restoration actions in the context of their ability to maintain or increase resilience of river ecosystems and salmon populations. Results of their review are briefly summarized in Table A.1-1.

Table A-1.1 Effects of tributary habitat improvement actions on ameliorating climate change effects and improving resilience (summarized from Beechie et al. [2013]).

Action Type	Effects of Action
Restoring riparian function	Restoring riparian areas through replanting of native trees can mitigate stream temperature increases via increased shading. While such actions generally do not directly ameliorate stream flow changes, removal of certain non-native species that use more water than native species and provide less shade can ameliorate both increased stream temperatures and decreased flows. Riparian restoration can lead to modest increases in habitat diversity over the long term via formation of pools or hiding cover. Riparian restoration can be expected to increase ecosystem resilience in the sense that rivers with intact riparian buffers can buffer ecological functions against changes in stream flow, but riparian restoration is unlikely to have significant effects on life history diversity and resilience.
Removing barriers	Removal of dams or other barriers can allow fish to access important upstream cool water habitats when downstream areas become too warm, thereby increasing habitat and life history diversity at the population and meta-population scales. Where dams or other structures contribute to reduced low flows or increased stream temperature, dam removal can also ameliorate low base flow and high temperatures by restoring downstream movement of sediment and water.
Reconnecting floodplains	Floodplain reconnection actions, which typically include reconnection or creation of side channels and sloughs, removal or setback of levees and dikes, and re-meandering of dredged or straightened channels, can ameliorate peak flow increases by storing flood water and reducing flood peaks or by increasing the availability of velocity and thermal refugia. Similarly, removing levees or re-meandering channels can ameliorate temperature increases by increasing the length of hyporheic flow paths beneath the floodplain, which can cool water during the summer. Restoring floodplain connectivity can also increase habitat diversity and facilitate increased life history diversity within a population, which has been linked to increased population resilience. Floodplain reconnection actions generally do not ameliorate base flow decreases.
Restoring incised stream channels	Restoration of incised stream channels can restore floodplain aquifer storage, increase summer base flow and decrease summer stream temperature, and increase availability of flood refugia. Some restoration techniques, such as use of beaver dams to increase sediment storage, have the added effects of increasing summer base flows, locally decreasing or buffering stream temperature, and increasing habitat diversity and productivity. Hence, restoration of incised channels has the potential to ameliorate climate-induced increases in stream temperature and effects on peak flows and low flows, and also to increase life history diversity through creation of off-channel and pond habitats.

Action Type	Effects of Action
Restoring stream flow regimes	**Flood flows** are caused by logging and forest roads, grazing activities, and impervious surfaces in urban areas, because water that would normally flow to streams slowly via subsurface flow is instead routed rapidly to streams through ditches. Actions to reduce routing of water directly from road ditches to the stream or, in an urban environment, to create additional stormwater retention structures or modify surface areas so that runoff is routed into groundwater storage rather than storm drains can help reduce these flood flows. Increased runoff and flood flows can also cause summer baseflows to decrease due to loss of infiltration and water storage in soils. Hence, reductions of grazing or logging effects on flood flows may also increase low flows in summer. **Low stream flows** are exacerbated by withdrawal of water from streams for irrigation or consumptive uses. Restoring water to streams through purchase of water rights or increased irrigation efficiency can dramatically increase low flows to streams and directly ameliorate climate-induced decreases in low stream flow or increased stream temperature. In some cases, restoring flow can also increase habitat diversity by restoring channel-forming flows that maintain habitat diversity and other ecological functions.
Improving stream structure and complexity	Actions such as adding large wood or spawning gravel to streams or re-meandering stream channels have been well documented to provide quick improvements in both physical habitat and fish production, although they do not restore the underlying disrupted process. They also do not generally ameliorate changes in temperature, base flow, or peak flows. Instream habitat actions can increase local habitat complexity (particularly if a large portion of the stream is treated), but such actions are unlikely to increase life history diversity or resilience of salmon populations.
Reducing erosion and sediment delivery to streams	In forested environments of the Pacific Northwest, sediment supply to stream channels is typically increased through surface erosion on unpaved roads or by increased landslides from roads or clearcuts. Climate-change-related increases in storm intensity and a shift from snow to rainfall may cause more frequent landslides in forest environments, especially where road management has not yet achieved reductions in landslide hazard. In croplands and grazing lands, efforts to reduce surface erosion can improve stream habitat by decreasing fine sediment in the streambed, increasing pool depth, or narrowing widened channels, but these actions will not ameliorate decreased low flows, increased flood magnitude, or increased stream temperature (although increased pool depth may create thermal refugia in rare cases). Moreover, these actions do little to increase habitat or life history diversity, except in cases where extremely high sediment supply has filled pools and reduced the diversity of habitat types.

Action Type	Effects of Action
Adding nutrients	Nutrient enrichment to compensate for lack of marine-derived nutrients from reduced salmon returns may be important to the productivity of naturally oligotrophic rivers where salmonid populations are food-limited. Nutrient additions, however, do not address the ultimate cause of low nutrient levels as a result of reduced salmon runs, and do not ameliorate climate change effects on stream flow, stream temperature, or habitat diversity. However, increased stream temperature increases the metabolism of juvenile fishes, which increases their food requirements, so where reduced nutrients and food resources have already compromised growth of juvenile salmonids, actions to increase nutrient supply may indirectly ameliorate temperature effects on salmonid growth rates. Maintaining this effect would require a consistent, long-term nutrient supplementation program.

A.2.2.5 Detecting Fish Response to Tributary Habitat Actions

Measuring the effects of habitat improvement for fish and other aquatic and riparian biota is "one of the great challenges of river and stream conservation" (ISAB 2018). Detecting a fish response to habitat actions is challenging for many reasons: actions encompass a wide range of locations, intensities, and sizes; they are implemented over a long period of time; fish may move in and out of a watershed throughout any evaluation period; the number of juveniles and the time they enter a watershed is dependent on variable environmental conditions in any given year; some actions, such as riparian planting and conservation easements, may take decades before they provide their full ecological benefits; and other actions, such as large wood placements and floodplain reconnection, provide more immediate benefits, but also evolve and accrue benefits over time. In addition, large areas of a watershed need to be improved to detect fish responses (e.g., Roni et al. [2010] reported that more than 20 percent of a watershed would need to be improved to measure a population/watershed-scale response to enhancement), and pre-treatment data and reference, or control, watersheds are needed to detect treatment effects at a watershed scale. Further, many habitat actions have complex effects that play out over large scales and are confounded by other effects (including climate and ocean conditions) that also influence salmon survival.

Importantly, this does not mean that the actions are not providing a benefit, especially when viewed in the context of long-term implementation of habitat improvement actions. Actions may be having a benefit even though that benefit cannot be detected in modeling or monitoring results for various reasons, including countervailing effects such as ocean conditions or increased predation, variability in life-stage survivals, the fact that not a large enough portion of a watershed or the right factors have yet been treated, and, in the case of models, uncertainty in assumptions or parameters.

The ISAB included a cogent discussion of this topic in its report on spring Chinook salmon in the upper Columbia River (ISAB 2018). Noting the complexities and constraints involved in large-scale experiments designed to measure a population response to habitat improvement actions, they discuss how other ways of evaluating possible fish responses can be used to argue for positive benefits that cannot be measured directly owing to other complexities or confounding factors. The monitoring results described above, and many others, are promising in that they address exactly the kinds of factors the ISAB recommended considering: they demonstrate that habitat is changing in response to the actions, that fish are using the restored habitat, that densities and growth rates are responding, and that improvements in survival have been measured in some cases.

A.2.3 Conclusion Regarding Scientific Basis for Tributary Habitat Improvement Actions

To draw conclusions about the benefits of tributary habitat improvements, we evaluated multiple lines of evidence, including knowledge of the basic relationships between fish and their tributary habitat, findings in the scientific literature about how changes in fish habitat affect fish populations, literature on the physical and biological effectiveness of tributary habitat improvement actions, correlation analyses, results from monitoring in the Columbia River basin designed to evaluate the effects of various actions on tributary habitat limiting factors and on salmon and steelhead population response, and the results of life-cycle models. All of this information continues to confirm our findings in the 2008 biological opinion, its 2010 and 2014 supplements, and the 2019 biological opinion regarding habitat and fish response. Overall, the weight of evidence continues to support the basis for implementing tributary habitat improvement actions, and our previous conclusion that many habitat restoration actions can improve salmon abundance and productivity over relatively short periods. Examples of such actions include increasing instream flow, improving access to blocked habitat, reducing mortality from entrainment at water diversion screens, placing of logs and other structures to improve stream structure, and restoring off-channel and floodplain habitat. For other habitat improvements, such as reduction of excess fine sediment in spawning areas and restoration of riparian vegetation, it may take decades to realize their full benefit.

A.3 Analysis of Effects of Tributary Habitat Actions

A.3.1 Methods Used in 2008 Biological Opinion and its Supplements

The approach used in the 2008 biological opinion for analyzing the effects of tributary habitat actions relied on using expert judgment to estimate the change in habitat function as a result of implementing habitat improvement actions, and then using an empirically based model to estimate the overall change in habitat function and a corresponding change in egg-to-smolt survival that would result from that change in habitat function. A monitoring and evaluation program was in place to track the effects of tributary habitat actions and to provide input for the adaptive management framework within which the Action Agencies implemented habitat improvement actions.

This method was developed by the Remand Collaboration Habitat Workgroup, which was convened in 2006 at the request of the Policy Work Group formed as part of the court-ordered remand of NMFS' 2004 biological opinion for the CRS. Members of this workgroup represented the states, tribes, and Federal agencies (including NMFS) involved in the remand collaboration process and were selected for their technical expertise. The workgroup developed methods based on both expert opinion and review of scientific information (such as known egg-to-smolt survival relationships for Chinook salmon and steelhead) that could be applied consistently to all populations. For additional detail on the methods used in the 2008 biological opinion, see Section 3.1.1.6 of NMFS (2014); Appendix C of the 2007 Comprehensive Analysis (Appendix C, Attachment C-1 and Annexes 1–3, USACE et al. [2007]); and Appendix C of Milstein et al. (2013).

A.3.2 Methods Used in 2019 and 2020 Biological Opinions

We noted in the 2014 supplemental biological opinion that life-cycle models (actually, a suite of models within a common framework) were under development and should be available for future CRS analyses (NMFS 2014). These models were developed through the Adaptive Management Implementation Plan process and have been peer-reviewed by the ISAB (ISAB 2013, 2017).

Life-cycle models are increasingly being used in an effort to better predict the outcome of various management scenarios in relation to Pacific Northwest salmonids. By modeling multiple stages and transitions, life-cycle models can determine where bottlenecks in survival or capacity limit recovery, or make projections about population abundance and extinction risk under various scenarios of potential future conditions. Life-cycle models are well-suited to management of salmonid populations because the salmonid life cycle encompasses large geographic ranges and multiple opportunities to address human impacts. Developing effective management strategies involves balancing a range of potential actions across life stages, habitat types, and anthropogenic impacts. The full life-cycle modeling framework used in this opinion is documented in Zabel and Jordan (2020), with additional detail on modeling of tributary habitat improvement actions provided in Pess and Jordan (2019).

The life-cycle modeling effort includes the development of several tributary habitat models in collaboration with key state and tribal scientists. These models represent an evolving method to estimate salmonid population response to habitat improvement actions. They allow detailed estimation of juvenile habitat capacity and survival, making it possible to evaluate changes in capacity and survival under various management or restoration scenarios. All the models are framed in the matrix life-cycle modeling format originally described by the Interior Columbia Technical Recovery Team (ICTRT) and Zabel (2007), although each is adapted to use the different levels of information available to populate its freshwater life stages (Zabel et al. 2017, Pess and Jordan 2019, Zabel and Jordan 2020).

In the 2019 biological opinion and in this opinion, we consider results of these tributary habitat models for some spring Chinook salmon populations in evaluating the effects of actions implemented to date and the effects of the proposed action. We expect to continue model development for additional populations in the future. As noted below, we also anticipate using these tributary habitat models to inform implementation of proposed tributary habitat actions over the 15-year implementation period of this opinion.

In addition to using life-cycle models to evaluate tributary habitat actions for some populations, we also evaluated proposed tributary habitat actions using qualitative considerations. Both the quantitative methods and qualitative considerations are described below.

A.3.2.1 Quantitative Methods: Modeling the Effects of Tributary Habitat Actions

Using life-cycle models to estimate fish population response to a suite of tributary habitat actions involves the following steps:

1. Estimate life-stage-specific habitat capacities: To estimate how a population will respond to various types and intensities of tributary habitat improvement actions, modelers first need to estimate life-stage-specific habitat capacity, or how many fish a system might support at a specific life stage under historical, current, or proposed habitat conditions. This requires a compilation of available data on parameters such as life-stage-specific capacity, survival, and abundance. Models can then be developed at the appropriate level of detail given the available data and understanding of limiting factors. If data to parameterize a model are lacking, modelers must choose whether to collect the necessary data or to utilize the parameters and functional relationships from nearby basins or the general literature to inform the model. Zabel et al. (2017) and Zabel and Jordan (2020) describe and compare different methods to estimate juvenile rearing capacity at several spatial scales and extents. Pess and Jordan (2019) provide additional discussion on the approaches used to estimate juvenile rearing capacity.

2. Calibrate life-cycle models to fish data and current conditions: To make models more accurately reflect fish data and current conditions, modelers calibrate them, meaning that they adjust model parameters based on available data. Calibration techniques range from straightforward to complex. For example, a simple approach would be to develop life-cycle-model parameters independently based on the literature and reach-scale data, and then adjust the reach-scale parameters to produce population-scale predictions that are in closer agreement with basin-scale fish data. More complex approaches involve the use of statistical model fitting, where statistical techniques, such as state-space models, are used to derive parameters directly from local fish abundance data, where available. This approach allows for uncertainty in the data to be carried through all stages of the model and be reflected in the outputs. Approaches to calibration are discussed in more detail in Pess and Jordan (2019).

3. Evaluate how habitat restoration scenarios would change habitat capacity and survival: If managers develop several restoration scenarios, modelers can evaluate how each restoration scenario would change habitat capacity and productivity from existing or historical conditions. They do this by comparing the current or proposed stream condition to experimental or observational data that can inform how habitat capacity, fish growth, or fish survival changes under different habitat scenarios.

Habitat is typically evaluated by looking at habitat quantity (e.g., stream channel area, pool frequency), habitat quality (e.g., floodplain condition, fine sediment levels, riparian condition), environmental conditions (e.g., stream temperature, streamflow), indicators of habitat quality (e.g., adjacent land use), and causes of habitat degradation (e.g., water diversions and barriers). Each of these variables can have an impact on salmon habitat capacity and survival at one or more life stages.

Habitat changes between restoration scenarios and current or historical conditions are then translated into changes in life-stage capacity or survival. For example, addition of wood structures to a channel may increase both summer and winter rearing capacity and change both summer and winter rearing life-stage survival rates. By contrast, a change in spawning gravel quality by decreasing percentage of fine sediment would not alter spawning capacity, but would increase egg-to-fry survival. Pess and Jordan (2019) document the methods used for translating habitat actions into life-cycle model inputs. They also contrast methods and results using "data rich" and "data poor" environments in the Upper Grande Ronde, Wenatchee, and Upper Salmon River basins.

In general, changes in habitat quantity translate into changes in habitat capacity, and changes in habitat quality translate into changes in life-stage survival. The functional relationships between a habitat change and the corresponding change in capacity or survival are typically developed from literature or from local empirical relationships. For example, numerous studies of fine sediment effects on egg-to-fry survival show that egg-to-fry survival decreases with increasing fine sediment, and both general and species-specific equations can be developed to translate changes in fine sediment into a change in survival. On the other hand, local data may indicate that smolt production of a particular species is related to a stream parameter such as summer streamflow, and the statistical relationship between streamflow and survival can be used to quantify rearing survival in a life-cycle model. For additional detail on translating habitat quantity into habitat capacity estimates and translating habitat quality into survival estimates, see Pess and Jordan (2019).

4. Use life-cycle models to evaluate differences in fish production among scenarios: Finally, the changes in capacity and survival from the restoration scenarios are used as inputs to a life-cycle model to assess the overall change in salmon abundance and productivity (and, potentially, change in spatial structure and diversity) that would result from the restoration scenarios. For example, modelers might estimate that reconnecting a certain amount of floodplains will increase parr capacity in a particular stream by 10 percent. That information then becomes an input to a life-cycle model to evaluate whether that 10 percent increase in parr capacity will result in an increase in adult abundance or, alternatively, in falling below a quasi-extinction threshold. If there is strong density dependence after the parr stage (e.g., in overwinter survival), then the increased parr capacity might not produce many additional adults. In other cases, there might be a proportional increase in adult abundance.

Life-cycle models can vary considerably in complexity, particularly in the number and specificity of life stages included in the model. In general, more complex models allow for a greater range of restoration scenario development; however, they also require more data. Conversely, less complicated models accommodate a more limited range of restoration scenarios, but require less input data.

For this opinion, we considered modeling of the effects of tributary habitat actions implemented from 2009 through 2015 and proposed tributary habitat actions for certain populations in the Grande Ronde/Imnaha and Upper Salmon River major population groups (MPGs) of the Snake River spring/summer Chinook salmon ESU; for the Wenatchee River population in the Upper Columbia River spring-run Chinook salmon ESU, we considered the effects of tributary habitat actions implemented from 2009 through 2018 and proposed tributary habitat actions (see Cooney et al. [2020b], Jordan et al. [2020], and Jorgensen and Bond [2020]).[5] In some cases, modeling of additional habitat action scenarios, such as scenarios involving longer-term strategic implementation of actions, or scenarios involving random implementation of actions (see Pess and Jordan 2019), was also available and informed our understanding of the context for the proposed tributary habitat action.

For the Wenatchee spring-run Chinook salmon population, modelers evaluated how certain tributary habitat actions implemented in 2009 through 2018, as well as how certain actions proposed for implementation in 2021 through 2036, might change juvenile rearing capacity in major tributaries to the Wenatchee River (Jorgensen et al. 2013, 2017; Pess and Jordan 2019; Jorgensen and Bond 2020). The model can only assess the benefits to juvenile rearing capacity of actions to improve access and stream complexity. Actions implemented and proposed for implementation are broader in scope than those evaluated, but because the model does not evaluate the effects of actions such as returning flow to the stream, screening diversions, and restoring riparian areas, potential benefits of those types of actions are not included in the model results. Further, the modeling may not have captured all benefits attributable to the specific actions that were evaluated (Jorgensen and Bond 2020). There were four habitat actions completed during the period of 2009 through 2018 that were located in the spawning and rearing areas evaluated and that were quantifiable into changes in habitat capacity. These actions translated to a 7.6 percent increase in capacity in the Nason Creek watershed and a 1.7 percent increase in the White River watershed (Jorgensen and Bond 2020).

For the proposed actions, the modelers also had to make assumptions about what portion of the anticipated actions (which the Action Agencies identified at the MPG level) would be implemented in the Wenatchee River population, and where, when, and how. These assumptions are described in Jorgensen and Bond (2020). For example, modelers assumed that actions would be implemented in the same watersheds where they had been in the past (i.e., the White River,

[5] Although habitat improvement actions were underway in this ESU before 2009, modelers used 2009 as a starting point because they viewed actions completed before then as less likely to yield benefits as a result of having been more opportunistic, smaller actions implemented without the benefit of comprehensive tributary and reach assessments and other planning tools. In addition, systematic monitoring data to describe habitat conditions for use in the life-cycle models were not available prior to 2009. Metrics for actions completed in 2019 were not yet available at the time the life-cycle modeling was completed.

Nason Creek, and the Chiwawa River within the Wenatchee River subbasin); that habitat access actions would open habitat of type and quality similar to that currently available; and that actions to improve complexity would be implemented in locations adjacent to habitat currently in moderate or good condition. Based on model results, the proposed actions would increase juvenile rearing capacity by 3 percent in the Chiwawa River, 5.2 percent in Nason Creek, and 3.5 percent in the White River (Jorgensen and Bond 2020). (Projected changes in abundance of natural-origin spawners and extinction risk for this population as a result of these actions are captured in the life-cycle modeling results discussed in Section 2.6.3.1.12 of this opinion.)

For the Upper Salmon River spring/summer Chinook salmon MPG, modelers evaluated how certain tributary habitat actions implemented from 2009 through 2015 would affect juvenile rearing and spawning capacity in the Pahsimeroi, North Fork, East Fork, Upper Mainstem, and Yankee Fork populations. The model evaluated instream actions (i.e., actions to improve stream complexity and/or floodplain/side-channel connectivity) and actions to improve access. Because this model does not evaluate the effects of actions such as returning flow to the stream, screening diversions, or restoring riparian areas, benefits of such actions are not included in the model results. Further, the modeling may not have captured all benefits attributable to the specific actions that were evaluated. Modeling methods, assumptions, and results are documented in Pess and Jordan (2019) and in Jordan et al. (2020). Based on the model results, actions implemented in 2009 through 2015 increased juvenile rearing capacity by 7 percent in the Lemhi, 9.4 percent in the Pahsimeroi, 2 percent in the North Fork, less than 1 percent in the East Fork and Upper Mainstem, and 1 percent in the Yankee Fork. The actions increased spawning capacity by less than 0.5 percent in most of these populations, and by 2.1 percent in the Lemhi population (Jordan et al. 2020).

Modelers also evaluated the effects of some types of the proposed tributary actions on populations in this MPG. The proposed tributary habitat actions for 2021 through 2036 for this MPG include flow protection and enhancement, screening of diversions, access, stream complexity, and riparian habitat improvement. As noted above, however, the model can only assess the benefits to juvenile rearing and adult spawning capacity of instream actions to improve stream complexity or floodplain/side-channel connectivity and actions to improve access, so the effects of actions such as returning flow to the stream, screening diversions, and restoring riparian areas are not included in the model results. For the analysis, modelers assumed that the Action Agencies’ efforts would be focused on the Lemhi, Pahsimeroi, and Upper Mainstem populations. Modelers also made other assumptions, documented in Pess and Jordan (2019) and Jordan et al. (2020) (e.g., habitat access projects were assumed to open habitat of similar type and quality to that currently available, and complexity actions were applied to improve the quality of habitat currently in moderate or good condition). Based on model results, the proposed actions would increase juvenile rearing capacity by 12.3 percent in the Lemhi, 19.8 percent in the Pahsimeroi, and 10.5 percent in the Upper Mainstem; spawning capacity would increase by 7.8 percent in the Lemhi, 19.8 percent in the Pahsimeroi, and 6.9 percent in the Upper Mainstem. (Projected changes in abundance of natural-origin spawners and extinction risk for this population as a result of these actions are captured in the life-cycle modeling results discussed in Section 2.2.3.1.12. of this opinion.)

For the Grande Ronde/Imnaha River spring/summer Chinook salmon MPG, modelers evaluated: 1) the impacts of tributary habitat actions implemented in 2009 through 2015 (Pess and Jordan 2019, Cooney et al. 2020); 2) the impacts of the tributary habitat actions in the proposed action for this opinion (Cooney et al. 2020); 3) several scenarios of long-term implementation of tributary habitat actions, including specific actions called for in Appendix A (Northeast Oregon management unit) of the Snake River Spring/Summer Chinook Salmon and Steelhead ESA Recovery Plan (NMFS 2017b), and a scenario focused on restoring stream structure and reducing temperatures through the combined effects of riparian shade and achieving natural channel structure and width/depth ratios (Pess and Jordan 2019). Modeling methods, assumptions, and results are documented in Pess and Jordan (2019) and Cooney et al. (2020b). Modelers concluded, for example, that in Catherine Creek, the actions implemented in 2009 to 2015 would increase summer parr rearing capacity by 21 percent within a few years of implementation. For the Catherine Creek population, the proposed actions would increase summer-rearing capacity by an additional 75 percent after full implementation (i.e., by 2036), and for the Upper Grande Ronde population, by 26 percent. As benefits of actions implemented under the proposed action continue to accrue, functional parr capacity would increase by a total of 100 percent in Catherine Creek and 33 percent in the Upper Grande Ronde at 24 years after full implementation (Cooney et al. 2020b; Pess and Jordan 2019). (Projected changes in abundance of natural-origin spawners and extinction risk as a result of tributary habitat actions are captured in the life-cycle modeling results discussed in Section 2.2.3.1.12 and Appendix C of this opinion, and in Zabel and Jordan 2020.)

Generally the modeling shows that 1) actions implemented in 2009 through 2018 will have small-to-moderate positive effects on habitat capacity; 2) implementation of the proposed tributary habitat actions evaluated in this biological opinion will have small-to-large positive effects on abundance and extinction risk; 3) implementation of actions at similar or enhanced levels of effort for a longer time period, consistent with recovery plan priorities and best principles of watershed restoration would have even greater benefits (e.g., see discussion of life-cycle modeling results for the Grande Ronde spring/summer Chinook salmon MPG in Pess and Jordan 2019).

A.3.2.2 Qualitative Considerations Used in 2019 and 2020 Biological Opinions

In addition to considering the results of life-cycle modeling of salmonid population response to habitat improvement actions, we also used qualitative considerations to evaluate tributary habitat actions. The qualitative considerations included the following factors:

A.3.2.2.1 Extent to Which Actions Address Identified Limiting Factors or Life Stages

A limiting factor is a factor that controls the growth, abundance, or distribution of a population in an ecosystem. Tributary habitat improvement actions will be most beneficial if targeted at the factor or life stage that is most limiting. We considered the extent to which tributary habitat actions implemented and proposed for implementation addressed identified limiting factors and life stages. Our qualitative evaluation of this factor for the proposed tributary habitat action is necessarily coarse in scale since the proposed actions are identified at the MPG scale. However, based on the Action Agencies' past record of implementation, their stated commitment to continue to improve strategic implementation, and the types of actions they have identified for implementation, we are confident that, in general, actions to be implemented will target limiting factors that have been identified using best available information.

A.3.2.2.2 Potential to Improve Tributary Habitat Conditions

Our qualitative evaluation also considered the potential for improvements in tributary habitat capacity and/or productivity in the targeted populations. This consideration is important because it speaks to the potential to achieve improvements in abundance, productivity, spatial structure, and diversity as a result of implementing tributary habitat improvements. Our evaluation of the potential to improve tributary habitat conditions was informed by ESA recovery plans for interior Columbia Basin salmon and steelhead (UCSRB 2007; NMFS 2009, 2015, 2017a, 2017b), the most recent ESA 5-year status reviews (NMFS 2016a, 2016b, 2016c), the focal population analysis for Snake River spring/summer Chinook salmon (Cooney et al. 2020a; also see additional discussion below), the ISAB's 2015 examination of density dependence in salmon and steelhead in the Columbia River basin (ISAB 2015), and other information. Again, our qualitative evaluation of the proposed tributary habitat action is necessarily coarse since the proposed actions are identified at the MPG scale. However, based on our evaluation and on the Action Agencies' statements regarding the populations where they intend to focus implementation of tributary habitat improvement actions (BPA et al. 2020), actions will target populations where there is potential to improve tributary habitat productivity.

A.3.2.2.3 Role of Populations in ESA Recovery Scenario

NMFS has completed ESA recovery plans for all listed salmon and steelhead in the Columbia River basin (UCSRB 2007; NMFS 2009, 2013a, 2015, 2017a, 2017b). These recovery plans provide: 1) recovery goals, 2) management actions to achieve the goals, and 3) estimates of the time and cost required to carry out the actions. The plans also provide additional information to help frame and prioritize recovery actions, including descriptions of the status of the species; identification of limiting factors and threats; and "scenarios" for recovery. Recovery scenarios are based on the biological viability criteria developed by technical recovery teams (TRTs) to define conditions that, when met, will describe viable populations and species.[6]

The biological viability criteria are consistent with the hierarchical population structure that is critical to the resilience and long-term survival of salmon and steelhead. Each ESU or DPS consists of multiple independent populations that spawn in different watersheds throughout the

[6] NMFS appointed two TRTS for Columbia Basin: the Willamette/Lower Columbia TRT and the Interior Columbia TRT. This discussion focuses on the ICTRT, but the work of both Columbia Basin TRTs, and of all West Coast TRTs, was based on the same scientific principles (e.g., McElhany et al. 2000) and was generally consistent with each other.

ESU's or DPS's range. Additionally, within an ESU or DPS, independent populations are organized into larger groups known as major population groups (MPGs). MPGs are groups of populations that share similarities within the ESU or DPS (ICTRT 2005). The viability criteria are designed to assess risk for abundance/productivity and spatial structure/diversity at the population level. These population-level assessments are then considered in the context of criteria for how many and which populations within an MPG need to be at what status for the MPG as a whole to have a low risk of extinction, consistent with de-listing. The viability criteria developed by the Interior Columbia Technical Recovery Team (ICTRT) are summarized briefly below and outlined in detail in Interior Columbia recovery plans (NMFS 2017a, 2017b, 2015, 2009; UCSRB 2007) and the ICTRT's technical report (ICTRT 2007).

ESU/DPS viability criterion: All extant MPGs and any extirpated MPGs critical for proper functioning of the ESU or DPS should be at low risk.

MPG-level viability criteria: The following six criteria should be met for an MPG to be regarded as at low risk:

1. At least one-half of the historical populations within the MPG (with a minimum of two populations) should meet viability standards.[7]
2. At least one population should be classified as highly viable.[8]
3. Viable populations within an MPG should include some populations that are classified (based on historical intrinsic potential) as "very large," "large," or "intermediate." In particular, very large and large populations should be at or above their composite historical fraction within each MPG.
4. All major life-history strategies (e.g., spring and summer run timing) that were present historically within the MPG should be represented in populations meeting viability requirements.
5. Remaining MPG populations should be maintained with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and to preserve options for ESU/DPS recovery.
6. For MPGs with only one population, the population must be highly viable.

Population-level criteria: The ICTRT also defined population-level criteria for evaluating the status of the individual populations. These criteria describe a viable population based on

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[7] This means that, based on evaluation of population-level abundance/productivity, spatial structure, and diversity, using methods recommended by the ICTRT, a population should have a low (<5 percent) risk of extinction over a 100-year time frame.

[8] This means that, based on evaluation of population-level abundance/productivity, spatial structure, and diversity, using methods recommended by the ICTRT, a population should have a very low (<1 percent) risk of extinction over a 100-year time frame.

the four viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity).

Thus, the criteria for determining whether an MPG is at low risk allow for some flexibility in terms of which populations will be targeted for a particular recovery level to achieve a low risk MPG. The ESA recovery plans provide some additional guidance on which populations are targeted for viable, highly viable, or maintained status to achieve ESA recovery. This is relevant to the effects analysis because, in general, efforts focused on populations that need to achieve viable or highly viable status will be more valuable to near-term and long-term recovery efforts.

A.3.2.2.4 NMFS Focal Population Analysis

To provide strategic guidance for implementation of recovery plans, NMFS has developed the concept of focal populations. The intent of this concept is to develop and apply criteria to identify populations where tributary habitat recovery efforts should be focused in the short term (i.e., a 5- to 10-year time frame) to contribute to both near-term improvements and long-term recovery goals. This concept and the method used to identify focal populations are described in detail in Cooney et al. (2020a).

The importance of sequencing or prioritizing restoration and recovery efforts over time to optimize conservation outcomes has gained increased attention in the conservation literature (e.g., see Drechsler and Wissel 1998, Willi et al. 2006, McBride et al. 2010, Wilson et al. 2011, Aitken et al. 2013). Specifically, it is important to explicitly consider the role of starting conditions and inherent limitations on available resources when determining how to maximize gains toward long-term goals. It is also important to consider the time required for restoration actions to achieve desired improvements in habitat conditions and the associated lags in benefits to fish. In many ways, the basic principles for multi-population-level sequential planning strategies parallel the advice regarding protection and restoration within populations (e.g., Beechie et al. 2010).

Using ESA recovery plans and ICTRT work as starting points, supplemented by new information and additional considerations, NMFS developed an approach to identify short-term opportunities to benefit key populations, consistent with longer-term ESA recovery goals. Criteria for identifying focal populations include: 1) VSP characteristics (abundance, productivity, spatial structure, and diversity; intrinsic potential [population size and complexity]; and meta-population characteristics); 2) current population status (quasi-extinction risk, current abundance relative to minimum thresholds for recovery, hatchery supplementation, and gaps between current status and target status to achieve recovery goals); 3) relative habitat improvement potential; and 4) climate change vulnerabilities. For details on these criteria and how they were applied, see Cooney et al. (2020a).

The focal population concept is intended to complement other approaches to help prioritize activities in the basin in support of recovery plan implementation, CRS-related actions, and other processes. For example, results from the focal population analysis could contribute to sequencing future efforts to develop more strategic action plans at the population or MPG level. Accordingly, in our qualitative evaluation of the effects of tributary habitat actions under this opinion, we considered alignment between the Action Agencies' efforts and the focal populations. We expect to work with the Action Agencies and co-managers over time to more closely align tributary habitat efforts with focal populations.

A.3.2.2.5 Action Agencies' Track Record of Implementation

Our qualitative evaluation also considered the Action Agencies' track record of implementation, their relationships with local implementing partners, and their commitment to continuing to improve implementation through adaptive management. Under the 2008 biological opinion, the Action Agencies implemented substantial tributary habitat improvement actions; increased investments in the tributary habitat; and improved the scope, biological rigor, and collaborative regional effort directed at implementing tributary habitat actions (BPA et al. 2013, 2016; NMFS 2014). They continued implementation of these actions under the 2019 biological opinion (NMFS 2019, BPA et al. 2020). The Action Agencies have stated their commitment to continuing to improve strategic implementation of tributary habitat actions, consistent with best available science related to habitat restoration; to convene a tributary habitat steering committee to oversee program implementation and a tributary technical team to provide scientific input to program implementation; to report on implementation using metrics that will allow NMFS to evaluate the success of the actions; and to conduct RME to assess tributary habitat conditions, limiting factors, action effectiveness, and to address associated critical uncertainties (BPA et al. 2020).

A.3.2.2.6 Short-term Negative Effects of Implementing Tributary Habitat Improvement Actions

We considered short-term negative effects that could result from implementation of tributary habitat improvement actions. Tributary habitat improvement actions will have long-term beneficial effects at the action and subbasin scale. Adverse effects during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples of such short-term effects include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in the Habitat Improvement Programmatic Consultation (NMFS 2013b, 2020). The positive effects of these actions on habitat function and salmon and steelhead populations (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, and enhanced channel structure) will be long term.

A.3.2.3 Conclusion Regarding Methods Used to Analyze Effects

NMFS has determined that the approach used to evaluate the effects of proposed tributary habitat improvement actions is based on best available science. The qualitative considerations used in our analysis are comprehensive and based on best available information. In addition, we considered quantitative life-cycle model results that represent an improved method to estimate salmonid population response to a series of habitat improvement actions.

The life-cycle models were developed in collaboration with key state and tribal scientists, and have been independently peer-reviewed by the ISAB (ISAB 2013, 2017). They allow detailed estimation of juvenile habitat capacity and survival, making it possible to evaluate changes in capacity and survival under various management or restoration scenarios. They are based to a greater extent on population-specific empirical relationships than were the methods used in the 2008 biological opinion, and they are based on a more complex and realistic representation of fish-habitat relationships and timing of benefits than the methods used in the 2008 biological opinion. Under the methods used in the 2008 biological opinion, expert judgment provided a large part of the determination of habitat function in all locations, given the limited extent of readily available empirical data and information. We expect that expert opinion will continue to play a role in the process of estimating habitat benefits (e.g., in estimating how specific actions or suites of actions will change habitat), but we also expect greater reliance on empirically and mathematically derived relationships as they evolve.

A.4 RME and Adaptive Management

The 2008 biological opinion and its 2010 and 2014 supplements (NMFS 2008, 2010, 2014) contained a robust and sizable RME program designed to evaluate tributary habitat conditions, fish use of tributaries, and the effects of tributary habitat improvement actions on habitat and fish. The collection, assembly, and analysis of data from that program has enhanced our understanding of the effects of tributary habitat improvement actions and provided new information to incorporate into decision-making on habitat action prioritization and design. Such RME continued to play an important role in implementation of tributary habitat actions under the 2019 CRS biological opinion and will continue to do so under the current proposed action.

The Action Agencies will continue to monitor habitat status and trends, conduct compliance and implementation monitoring, support habitat action effectiveness monitoring, and fund fish and habitat monitoring and research projects with regional partners to address critical uncertainties. The Action Agencies have also committed to engaging in a collaborative process with other regional partners to develop and implement a Columbia River basin tributary habitat RME strategy that will align with and directly support implementation of tributary habitat improvement actions.

In addition, the Action Agencies have committed to an adaptive management/decision support framework in which habitat action implementation will be guided by the Tributary Habitat Steering Committee, with input from a newly formed Tributary Technical Team. Comprehensive reviews of program implementation will occur at 5-year intervals, with the explicit recognition that such periodic reviews provide an opportunity to consider program adjustments based on NMFS' 5-year status reviews, new climate and fisheries science, and the ongoing development of life-cycle models and other tools for identifying, prioritizing, and evaluating the projected benefits of suites of actions (Appendix D of BPA et al. 2020).

A.5 Implementation Considerations

In the 2008 biological opinion and its 2010 and 2014 supplements, we described recent findings in the literature regarding approaches to watershed restoration. That literature emphasized the need to incorporate proper planning (including assessing the natural potential of a system and using that information to direct action location, design, and selection), sequencing, and prioritization into decision frameworks to best achieve habitat objectives. We noted the four principles outlined in Beechie et al. (2010) to help ensure that restoration was guided toward sustainable actions: 1) address the root causes of degradation, 2) be consistent with the physical and biological potential of the site, 3) scale actions to be commensurate with the environmental problems, and 4) clearly articulate the expected outcomes.

Recent literature, monitoring information, and life-cycle modeling continue to reinforce the principles outlined in Beechie et al. (2010) and the principle that if the wrong action is implemented in the wrong place or at the wrong time, desired habitat conditions will not be observed or sustained over time. Based on their literature review, Hillman et al. (2016) concluded that the actions that are most effective at producing desired habitat conditions are those that:

1. Address the life stage and habitat condition limiting fish performance. Salmonid response to habitat enhancement is based on whether or not the enhancement actions address the specific life stage and habitat factors limiting that population’s performance.

2. Consider, and are implemented in context with, fluvial and geomorphic conditions and are sequenced such that the effects of enhancement actions on habitat conditions are not limited by upstream watershed processes. Habitat improvement actions, including protection projects, are ineffective or the effects are short-lived if unaddressed upstream watershed processes degrade treatment sites.

3. Treat a large percentage of the stream or watershed. The literature indicates that the largest biological benefits are associated with treating more than 20 percent of a watershed. Treating small portions of degraded habitat has little biological effect at the watershed scale, and the treatments are often overwhelmed by upstream degraded habitat conditions. (Roni [2018] also noted that the total amount of restoration and the connectivity of the restored habitats are important drivers of population- or watershed-level response to restoration.)

4. Derive from detailed watershed assessments to determine disrupted processes and lost habitat. Limiting factors analysis, watershed assessments, reach assessments, and habitat and life-cycle modeling are tools that can be used to identify threats, problems, and limiting factors within a watershed.

5. Are implemented in the context of a watershed implementation plan that prioritizes locations and types of actions. The sequencing of actions needs to consider degraded

watershed processes and threats, and limiting life stages and habitats. The literature identified degraded upstream watershed processes as the most common factor affecting the success of enhancement projects.

6. Include adequate coordination among stakeholders, landowners, funding and monitoring entities, and implementers. A lack of landowner support can derail a well-designed implementation plan.

7. Incorporate effectiveness monitoring at a subset of projects. Monitoring data collected under an adaptive management framework provide information needed to determine if enhancement work should continue as planned or be refocused or redirected.

Hillman et al. (2016) also summarize findings regarding specific types of habitat improvement actions, and note the importance of protecting high-quality habitat and prioritizing the reconnection of spawning and rearing areas (particularly areas with high intrinsic potential). They recommend that use of instream structures be implemented in concert with actions that improve watershed processes. Instream structures often provide benefits that are realized more quickly than actions that improve watershed processes, but it is important that they be sized appropriately for the channel and designed to mimic natural accumulations.

The core components of these findings were reinforced by the ISAB in its review of spring Chinook salmon in the upper Columbia River (ISAB 2018). They noted that while further analysis of limiting factors was needed, "simply listing potential limiting factors and eliciting professional opinions will not provide an accurate or even relative basis for designing and ranking restoration actions in a recovery plan." They further noted that "analysis must include the full life cycle of the population and assess the effects of physical, environmental, ecological, and anthropogenic factors on adult spawners across multiple generations."

Pess and Jordan (2019) elaborate on some of these themes and demonstrate the utility of life-cycle modeling in both data-rich and data-poor situations for evaluating and choosing among alternative restoration scenarios. They note that it is the combined effect of all restoration actions that will determine the potential magnitude of change in salmon populations, and demonstrate how alternative restoration scenarios at the watershed-scale can be developed and evaluated to determine which suite of actions will likely provide the largest benefit to salmon populations. The purpose of these analyses is to help focus restoration efforts on the types, location, and level of actions that lead to a measurable and significant improvement to salmon populations. Specific methods for these analyses depend on local habitat and fish data availability, and may range from simple analyses based on coarse spatial and/or temporal resolution data to more detailed evaluations with higher resolution data. Therefore, while the richness of the data will determine the analysis type used to evaluate the salmon population response to a suite of potential restoration actions, we do have tools available for both data-rich and data-poor situations. Further, learning from data-rich scenarios will inform and support decision making in data-poor scenarios.

Another important consideration in identifying and prioritizing tributary habitat improvement actions is how those actions can contribute to climate adaptation and resilience for salmonids. Beechie et al. 2013 developed a decision support process for adapting salmon recovery plans that incorporates: 1) local habitat factors limiting salmon recovery, 2) scenarios of climate change effects on stream flow and temperature, 3) the ability of restoration actions to ameliorate climate change effects, and 4) the ability of restoration actions to increase habitat diversity and salmon population resilience.

We support the conclusions and evaluation approaches noted above regarding effective implementation of tributary habitat improvement actions, and we expect that the Action Agencies will continue working to implement the tributary habitat improvement actions consistent with the recommendations noted above so that their effectiveness will be enhanced.

A.6 Conclusion

For this opinion, we reviewed the literature on habitat restoration and re-affirmed the strong technical foundation for the tributary habitat program. We evaluated RME information and found that it also supported the foundation of the program. We determined that the methods we use to evaluate the effects of tributary habitat actions are based on best available science and information. We evaluated the effects of proposed tributary habitat actions quantitatively for some populations and qualitatively for all populations within the context of our understanding of limiting factors, habitat improvement potential, and recovery plan and focus population frameworks. We then qualitatively related these population-level changes to effects on the species or designated critical habitat. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered the Action Agencies' track record of implementation, as well as the strategic framework within which the Action Agencies were committing to implement the tributary habitat improvement actions. In addition, we considered the adequacy of the RME and adaptive management framework proposed to evaluate and support implementation of tributary habitat actions.

Over time, understanding of habitat limiting factors has improved, along with the tools and processes for identifying, prioritizing, and coordinating the locations and types of actions that will provide the greatest improvements. The completion of ESA recovery plans for all ESA-listed Columbia Basin salmon and steelhead, the continued development of life-cycle models and additional tools that the Action Agencies and others have developed (e.g., tributary and reach assessments), should further enhance the ability to implement actions within a strategic framework. The Action Agencies' continued development and support of the local partnerships and the implementation infrastructure they have developed over the past 10-plus years should also contribute to this effort. Thus, we expect that future habitat restoration actions will target actions strategically to address limiting factors in a manner that contributes to both short-term and long-term benefits to VSP parameters, with a focus on populations that are important to achieving long-term recovery goals.

Implementation of the tributary habitat actions analyzed in this opinion, if implemented as described in the proposed action, will provide near-term and long-term benefits to the targeted populations. Actions implemented to ameliorate limiting factors for any population would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. Where such actions are implemented consistent with the strategic approach outlined in the proposed action (i.e., consistent with ESA recovery plan population priorities and the best available science [e.g., watershed assessments] and modeling information that informs questions related to what kind of actions will be most beneficial where, in what sequence, and at what scale), these benefits would be enhanced. In addition, certain types of actions are also likely to increase climate change resilience. For example, actions to restore riparian vegetation, streamflow, and floodplain connectivity and to re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, and thereby improve stream conditions, habitat diversity, and population resilience to certain effects of climate change. Improvements in tributary habitat are likely to contribute to improvements in all four VSP parameters for the targeted populations. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and could take 50 years or more for actions such as restoring riparian areas)—and fish populations also need sufficient time to respond. Therefore, it is unlikely that the full benefits of these actions will be realized in the timeframe of this proposed action. Further, to yield significant improvements, it is necessary to implement a large scale and scope of habitat improvement actions (e.g., implementation over a 25-year time period or longer) and to implement actions throughout a large portion of each watershed. Thus, it is important to consider the results of the habitat actions to be implemented under this proposed action in the context of the effects of long-term implementation of habitat actions.

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Appendix B – Avian Predation Management

Note: In some cases, predation rate estimates in this appendix differ from those reported in the 2019 CRS Biological Opinion. The 2019 CRS Biological Opinion used results from some reports with relatively small datasets or generated using methods that are now out-of-date. For example, before 2014, most predation rates were reported as minimum estimates because they had not been corrected for the proportion of tags that the birds deposited at off-colony locations (e.g., loafing, roosting, and foraging sites) or the proportion of deposited fish tags that were lost (i.e., not detected) before scanning the colony at the end of nesting season (e.g., blown off the colony during wind storms, washed away during flooding events, or otherwise damaged during the course of nesting season) (Evans and Payton (2020a). In draft tables produced for the regionally supported Avian Predation Synthesis Report, to be completed in September 2020, Evans and Payton (2020a) report updated predation rate estimates that have been corrected for PIT tag deposition and detection probabilities for all colonies and years where adequate data were available for analysis. This retrospective analysis of historical PIT tag datasets provides a more accurate and standardized estimate of avian predation rates across years, waterbird species, and colony locations than those previously reported in the researchers' annual reports or NMFS' biological opinions.

In addition, the CRS Action Agencies and U.S. Fish and Wildlife Service requested a change in the definitions of the pre-management and post-management time periods for the managed colonial waterbird colonies. In Evans and Payton (2020a), the management periods begin when actions to reduce colony size were initiated, regardless of whether those actions resulted in a significantly reduced colony size that year.

B.1 Introduction

Research shows that Caspian terns (*Hydroprogne caspia*) and double-crested cormorants (*Phalacrocorax auritus*) nesting on East Sand Island in the Columbia River estuary have consumed more than 10 to 20 percent of the juvenile Endangered Species Act (ESA)-listed Chinook and steelhead migrating from the interior Columbia Basin in some years (USACE 2015a; Evans et al. 2016). In response to these findings, NMFS provided several management measures in the 2008 FCRPS[1] biological opinion and 2010 and 2014 supplemental biological opinions to reduce the predation rates (NMFS 2008, 2010, 2014):

- RPA Action 45—The FCRPS Action Agencies will implement the Caspian Tern Management Plan. East Sand Island tern habitat will be reduced from 6.5 to 1.5–2 acres.

[1] In earlier biological opinions, the federal Columbia River System (CRS) was referred to as the Federal Columbia River Power System or FCRPS.

- RPA Action 46—The FCRPS Action Agencies will develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of warranted actions in the estuary.
  - This RPA action was modified in 2014 to read: "The FCRPS Action Agencies will develop a cormorant management plan (including necessary monitoring and research) and implement warranted actions to reduce cormorant predation in the estuary to Base Period levels (no more than 5,380 to 5,939 nesting pairs on East Sand Island."
- RPA Action 47—Inland Avian Predation: The FCRPS Action Agencies will develop an avian management plan (for Double-Crested Cormorants, Caspian Terns, and other avian species as determined by RME) for Corps-owned lands and associated shallow-water habitat.

During the 2018 Court-ordered remand of the 2014 supplemental opinion, the Action Agencies proposed to implement the management plans that resulted from the RPA actions. In this appendix, we document the Action Agencies' progress with respect to the management plans and current estimates of smolt predation rates.

B.2 Effects of Avian Predator Colonies in the Columbia River Estuary

B.2.1 Caspian Terns Nesting on East Sand Island

Terns first nested on East Sand Island in the lower Columbia River estuary in 1984, following the deposition of fresh dredged material at the eastern tip of the island in 1983. By 1985, vegetation covered the nesting site making it unsuitable for terns and by 1986 the colony had shifted to Rice Island, another dredged-material disposal site 16 miles upriver. In 1999 and 2000, the Corps' used social attraction mechanisms (decoys and pre-recorded callbacks) to move terns back to East Sand Island from Rice Island, in order to decrease the numbers of juvenile salmon and steelhead consumed by the terns (USACE 2015b).

This work was challenged under the National Environmental Policy Act (NEPA) by the Seattle Audubon Society, National Audubon Society, American Bird Conservancy, and Defenders of Wildlife. In 2002, the parties involved in the lawsuit reached a settlement agreement, which allowed the Corps' to continue to use social attraction devices to induce the terns to nest on East Sand Island, but also required the Corps' and U.S. Fish and Wildlife Service (USFWS) to produce an Environmental Impact Statement (EIS) for a plan to manage the terns in the long term. Subsequently, the federal agencies completed the Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary Final Environmental Impact Statement (USFWS et al. 2005). The USFWS and Corps' each issued their own records of decision (RODs) in 2006 (USFWS 2006, USACE 2006). Collectively, these documents are called the Caspian Tern Management Plan.

The Caspian Tern Management Plan called for the redistribution of 60 percent of the East Sand Island colony to new habitat (islands) to be constructed in Oregon, California, and Washington at a nesting area ratio of 2 new acres per acre reduction on East Sand Island. Because Caspian terns nested on an average of five acres from 2001 to 2004 on East Sand Island, approximately seven to eight acres of new suitable habitat would need to be created to reduce the East Sand Island habitat by 1 to1.5 acres (USFWS et al. 2005). Plans to create new habitat in Washington State were unattainable so a modified alternative was selected that involved constructing seven acres of new habitat in Oregon and California and reducing East Sand Island habitat to 1.5 to 2 acres so that a larger number of terns would remain on the island (3,125 to 4,375 pairs, assuming an average nesting density of 0.55 pairs/m^2).

Despite the subsequent reduction in nesting habitat on East Sand Island, the tern population continued to increase, with the number of nesting pairs on the island in 2013 (7,000) and 2014 (6,200) at twice that predicted in the 2005 EIS (USFWS et al. 2005) and in the Corps' 2006 Record of Decision (USACE 2015b). The Corps’ responded by preparing a smaller habitat area (1 acre) to reduce the size of the tern colony as prescribed in the Caspian Tern Management Plan with the expected outcome of 3,125 to 4,375 breeding pairs. Even with the Corps’ efforts, terns further increased their nesting density at East Sand Island to 1.36 nests/m^2 in 2016 (Roby et al. 2018). Thus, numbers of breeding pairs remained above the Caspian Tern Management Plan’s objective of 3,125 to 4,375 pairs.

The situation on East Sand Island changed in 2017. After increasing for a decade, the Caspian tern nesting density declined, dropping to 0.97 nests/m^2, with a peak size of about 3,500 breeding pairs in early June 2017. However, this decline in nesting at East Sand Island was met by an increase in tern interest at Rice Island, 16 miles upriver, where about 1,000 pairs of terns roosted, or tried to nest.[2] The increase in activity at Rice Island indicated that some of the birds displaced from East Sand Island had remained within the estuary, but were too far from the mouth of the river to include a larger proportion of marine forage fishes in their diet (i.e., diet was almost entirely salmonids). The Corps has increased dissuasion efforts and was able to keep terns from successfully nesting on Rice Island during the 2015 to 2019 nesting seasons (Harper and Collis 2018, USACE 2019).

By mid-June 2017, the size of the tern colony on East Sand Island was declining rapidly and all nesting attempts had failed (Roby et al. 2018). Terns completely abandoned the colony at the end of the month and stayed away for 10 days, an unprecedented event at this location. A smaller wave of nesting activity began in July and continued through early September with researchers reporting up to several hundred nests with eggs present on the colony at one time.

[2] Caspian tern activity at Rice Island had increased in 2015 following the placement of dredged material. The Corps built a berm on the downstream portion of the island in September 2015 to reduce line-of-sight visibility from areas where terns were prospecting for nests to the river. This reduced Caspian tern loafing or roosting in the upland placement area from about 6,000 individuals in 2015 to about 1,000 in 2017 (Evans et al. 2018a). A small proportion of these birds laid eggs, all of which were collected under annual depredation permits from USFWS.

However, these nests also failed and no Caspian tern young were raised on East Sand Island in 2017. This nesting failure could have been related to an increase in the rate of disturbance by bald eagles (*Haliaeetus leucocephalus*) and gulls (*Larus* spp.). Eagles harass terns to get them to drop fish they are bringing back to the nest (kleptoparasitism), and when other terns leave their nests during an eagle disturbance, gulls prey on the exposed eggs and chicks.

In 2018, the estimate of peak of peak colony size was 4,959 breeding pairs (Roby et al. 2019). This was significantly more than the estimate of 3,500 breeding pairs in 2017, but much lower than any other year since 2000 when the colony relocated to East Sand Island. Nevertheless, the estimated size of the East Sand Island tern colony in 2018 was still substantially larger than the target colony size of up to 4,375 breeding pairs specified in the management plan (USACE 2015). In 2018, nesting density was 1.23 nests/m^2, significantly higher than the 0.97 nests/m^2 in 2017, but lower than the 1.36 nests/m^2 in 2016 (Roby et al. 2019). Nesting density was slightly lower (was 1.11 nests/m^2) in 2019 (Roby et al. 2020). Peak colony size was reached in mid-June, 2019, at 3,860 breeding pairs, within the range targeted by the management plan (3,125 to 4,375 pairs).

C.2.1.1 Smolt Predation Rates by East Sand Island Caspian Terns

Evans and Payton (2020a) compare average annual predation rates before and after initiation of the Caspian Tern Management Plan (Table B-1). The findings indicate that predation rates have been, on average, significantly lower during the management period (2008 to 2018) than before management (2000 to 2007). Predation rates on steelhead, although variable, were linearly related to colony size, indicating that management actions to reduce numbers of terns on East Sand Island have resulted in lower annual predation rates at this colony (Evans et al. 2018a).

The presence of approximately 1,000 terns attempting to nest at Rice Island in 2017 (Evans et al. 2018a), and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018, USACE 2019), offset the lower predation rates at the East Sand Island colony to an unknown degree (Evans et al. 2018a). Because pre-management per capita predation rates on salmonids by nesting terns were two to three times higher at Rice Island than at East Sand Island, the USACE performs hazing and dissuasion activities to ensure that nesting attempts on Rice Island are not successful. The forage base at East Sand Island includes several species of marine fishes so that the same number of terns is likely to eat fewer salmonids at this location (Roby et al. 2002).

Table B-1. Average annual predation rates (with 95 percent credible intervals) on Snake River (SR), Upper Columbia River (UCR), Upper Willamette River (UWR), Mid-Columbia River (MCR), Lower Columbia River (LCR), and Columbia River (CR) salmonids by Caspian terns at East Sand Island. The pre-management time period is defined as the period before actions to reduce colony size were first implemented. Comparable estimates are not available (NA) for some time periods. An asterisks (*) indicates statistically credible differences between management periods for a salmonid species. Source: Evans and Payton (2020a).

Salmonid ESU/DPS	Pre-management Period	Management Period
	2000-2007	2008-2018
SR sockeye salmon[a]	NA	1.8% (1.4-2.2)
SR spring/summer Chinook salmon	5.2% (4.6-6.0)	2.1% (1.9-2.4)*
UCR spring Chinook salmon	4.3% (3.7-5.1)	1.9% (1.6-2.2)*
SR fall Chinook salmon	2.9% (2.4-3.4)	1.0% (0.8-1.2)*
SR steelhead	25.3% (22.7-28.3)	10.7% (9.8-12.0)*
UCR steelhead[b]	17.2% (15.2-19.5)	11.0% (10.0-12.5)*
MCR steelhead[c]	17.1% (14.0-22.0)	10.1% (9.1-11.4)*
LCR Chinook salmon[d]	4.1% (3.2-5.6)	2.5% (2.2-2.8)*
LCR steelhead[e]	15.2% (11.7-20.7)	10.4% (9.4-11.4)*
LCR coho salmon[f]	2.6% (1.4-4.3)	3.1% (2.6-3.8)
CR chum salmon	NA	NA
UWR Chinook salmon[g]	1.4% (0.7-2.4)	1.7% (1.3-2.1)
UWR steelhead	NA	NA

[a] Predation rate estimates for SR sockeye salmon were not available in 2000-2008 and in 2016-2017.

[b] Predation rate estimates for UCR steelhead were not available in 2001.

[c] Predation rate estimates for MCR steelhead were not available in 2000-2006.

[d] Predation rate estimates for LCR Chinook salmon were not available in 2000-2006.

[e] Predation rate estimates for LCR steelhead were not available in 2000-2006.

[f] Predation rate estimates LCR coho salmon were not available in 2000-2006 and in 2012-2016.

[g] Predation rate estimates for UWR Chinook salmon were not available in 2000-2006 and in 2017.

C.2.1.1.1 Tern Predation on Lower Columbia River Chinook and Coho Salmon and Steelhead

The predation rates in Evans and Quinn (2020) are based on the number of passive integrated transponder (PIT) tags detected on East Sand Island as a proportion of the number of tagged smolts that passed Bonneville Dam (or Sullivan Dam at Willamette Falls for Upper Willamette River Chinook salmon). Relatively few PIT-tagged smolts from Lower Columbia River ESUs and DPSs pass Bonneville Dam—which lies upriver from most of the spawning and rearing areas used by these species—so this method has not previously been applied. However, Sebring et al. (2013) estimated predation rates on specially PIT-tagged subyearling hatchery smolts from the Lower Columbia River (LCR) Chinook salmon ESU during 2002 to 2010. After recovering PIT tags from the East Sand Island tern colony, they estimated a minimum average annual predation rate[3] on these hatchery smolts of 4 percent. Sebring et al. (2010) also estimated a 3 percent minimum predation rate on PIT-tagged hatchery-origin LCR coho salmon by terns nesting at East Sand Island.

[3] Sebring et al. (2013) provide minimum predation rates because their estimates were not corrected for PIT-tag detection probabilities on East Sand Island. In addition, the samples were not representative of the Lower Columbia River Chinook salmon ESU at-large because they consisted only of subyearling hatchery-origin fish.

More recently, Evans and Payton (2020a) estimated Caspian tern predation rates for LCR Chinook salmon, LCR coho salmon, and LCR steelhead using PIT tag recoveries adjusted for deposition rates as estimated in the past for interior Columbia salmonids (e.g., Evans et al. 2019a). Evans and Payton (2020a) estimate a tern predation rate on LCR Chinook salmon for the pre-management period (4.1 percent) that is very similar to the minimum predation rate estimate (4.0 percent) in Sebring et al. (2013). However, Evans and Payton (2020a) report much higher average tern predation rates on LCR steelhead: 15.2 percent on LCR steelhead before the start of colony management on East Sand Island and 10.4 percent during the management period. Their estimate of predation rates on LCR coho salmon appear unchanged since the start of tern colony management (3.1 percent compared to 2.6 percent during the pre-colony management period; the difference is not statistically credible, Table B-1)).

C.2.1.2 Summary—Impacts of Caspian Terns in the Columbia River Estuary

The nesting attempts by terns on Rice Island in recent years indicate that this species' response to habitat reduction on East Sand Island has been in flux. However, the Corps has adjusted dissuasion efforts at dredge material islands in the lower Columbia River to ensure that terns do not nest successfully except on East Sand Island. The long term success of the management plan in reducing smolt predation is likely to depend on whether nesting densities remain low on East Sand Island and, if they do, whether birds move to areas outside the Columbia River basin rather than upstream to sites like Rice Island or the interior Columbia River plateau. Resightings of previously banded Caspian terns during the 2017 and 2018 nesting seasons showed that some moved from the estuary to the plateau or to Puget Sound, but that others were still coming to East Sand Island from other colonies in the Columbia basin and elsewhere in the Pacific Flyway (Roby et al. 2018, 2019a). One tern that was banded as a fledgling on East Sand Island and resighted there in 2016, was later seen at Corps'-constructed islands at Don Edwards National Wildlife Refuge in San Francisco Bay in 2017. The opposite occurred in 2018 when a tern banded in northern San Francisco Bay was spotted on East Sand Island (Roby et al. 2019). Given these movements, it may take more time for the colony on East Sand Island to stabilize. Based on the information in the upcoming Avian Predation Synthesis Report, NMFS will discuss with the state and tribal fish and wildlife managers whether the current colony management effort is adequate or whether the region should evaluate additional management actions.

The average annual predation rates reported in Evans and Payton (2020) indicate that these have been, on average, significantly lower during the management period (2008 to 2018) than before management (2000 to 2007). Predation rates on steelhead, although variable, were linearly related to colony size, indicating that management actions to reduce numbers of terns on East Sand Island have resulted in lower annual predation rates at this colony (Evans et al. 2018a). This is significant because steelhead are especially vulnerable to tern predation.

B.2.2 Double-crested Cormorants Nesting on East Sand Island

The double-crested cormorant colony on East Sand Island increased nearly threefold during 1997 to 2013 to about 14,900 breeding pairs (Turecek et al. 2018). The estimated per-capita smolt consumption by cormorants on East Sand Island was about four times higher than that of Caspian terns before management, both due to the larger number of breeding pairs and the higher food requirement of larger individual cormorants (Roby et al. 2013). Under 2008 RPA action 46 (as modified in the 2014 Supplemental FCRPS biological opinion), the Corps' developed the *Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary* (Cormorant Management Plan). The Cormorant Management Plan (USACE 2015a) called for a two-phased approach:

- Phase I – Reduce East Sand Island colony to 5,380-5,939 breeding pairs by implementing primarily lethal methods to reduce the population (i.e., four years of culling adults and three years of nest loss through egg oiling).
- Phase II – Transition to lower maintenance, primarily non-lethal techniques to ensure colony size does not exceed 5,380-5,939 breeding pairs. This would be accomplished via habitat modifications to reduce the availability of nesting habitat, supported with human hazing and limited egg take (500 eggs on East Sand Island and 250 at dredged placement sites in the upper estuary) to support the objectives of habitat modification and ensure the colony size does not exceed management objectives.

Phase I of the effort was expected to last four years, ending with a colony size of about 5,600 breeding pairs. However, the dispersal and subsequent nesting failure of this colony in 2016 and 2017 (see below) triggered the decision to end culling after April 2017, the third year of the implementation (see Table 5-3 in USACE 2015b). Early implementation of Phase II therefore began in 2018.

B.2.2.1 Double-crested Cormorant Colony Abandonment and Dispersal in 2016 and 2017; Late Nesting in 2018

In 2016, double-crested cormorants began nesting on East Sand Island in late April, but were absent between the week of 17 May and late June (Anchor QEA 2017). Researchers suspended ground surveys to avoid disrupting the remaining individuals, but reinitiated surveys when the larger numbers of birds returned. Peak numbers (19,544 double-crested cormorants; 9,772 nests) were present during the first week of July (Anchor QEA 2017). During the period when cormorants were absent from East Sand Island, many were observed on the Astoria-Megler Bridge, about 9 miles upriver. Counts on the bridge peaked at over 4,000 cormorants and about 550 nests in mid-June 2016 (Anchor QEA 2017).

Another abandonment and dispersal event occurred during the 2017 breeding season. Cormorants began staging and loafing on the beaches at the western end of East Sand Island in mid-April, but were unable to establish a colony (Turecek et al. 2018). They did have two brief periods of attendance during mid-May and early-June, but frequent disturbances by bald eagles resulted in partial or complete flushes to nearby beaches or to rafts on the water, usually in nearby Baker Bay. After a dispersal event in early June, cormorants did not sustain colony attendance except for 544 nests late in the season, but these did not appear to fledge any chicks. However, they did nest successfully on the Astoria–Megler Bridge with a peak count of about 6,000 individuals and more than 800 nests on 11 July (MacDonald 2017). Smaller numbers nested on the Lewis and Clark Bridge (Longview, WA); aids to navigation between Tongue Point, Oregon, and Skamokawa, Washington; and the electrical transmission towers near the Sandy River delta, Oregon.

The nesting chronology of the East Sand Island cormorant colony was roughly one month delayed in 2018 compared to that in 2004 to 2014, before implementation of the Management Plan (Turecek et al. 2019). Cormorants began loafing on the north beaches of East Sand Island in large numbers on 15 April, were first seen in the designated colony area on 9 May, and began roosting overnight on 15 May. Frequent predation pressure from bald eagles limited formation of the colony until early July. Cormorants responded to these disturbances by dispersing to nearby beaches and elsewhere off colony and/or retreating from bald eagles that landed within the colony. During flushes, bald eagles and gulls would walk through the colony and depredate eggs in the nests left unattended. Ultimately, nesting success in 2018 was estimated to be 1.8 young raised/active nest, identical to the average nesting success for the double-crested cormorant colony on East Sand Island before management (Turecek et al. 2019). In addition, a peak number of 1,736 breeding pairs nested on the Astoria-Megler Bridge in 2018 (Turecek et al. 2019). Altogether, a total of 8,485 pairs of double-crested cormorants attempted to breed in the Columbia River estuary in 2018, far higher than the average 5,660 breeding pairs envisioned by the management plan.

The Corps reduced monitoring effort at the East Sand Island double-crested cormorant colony in 2019, obtaining estimates of colony attendance and nesting success from aerial photographs. The USDA APHIS staff conducting hazing outside the established “sanctuary” at the west end of the island also provided occasional on-the-ground observations.

B.2.2.1.1 Phase II of the Double-crested Cormorant Management Plan: Terrain Modification at East Sand Island

The Corps implemented terrain modification at East Sand Island, as anticipated in the Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, between December, 2018, and March, 2019. About 125,000 cubic yards of upland material were excavated from an embayment on the western end of East Sand Island, reducing the elevation to 7.5 feet below the mean higher high water elevation. The length of the existing rock revetment along the southern shoreline was increased by 2,800 linear feet and a 600 linear foot revetment was built along the western shoreline to support integrity of the island and Columbia River Federal Navigation Channel. The purpose of the terrain modification project was to allow for more frequent inundation of the island, reducing the extent of habitat suitable for nesting by double-crested cormorants.

The Corps reported a peak population of about 4,500 individual double-crested cormorants occupying and attempting to nest on East Sand Island during the month of June, with a peak of 350 nests observed on June 25, but all were abandoned four days later (Scalfani 2019). The first chicks were observed in early September and no more than 51 nests successfully fledged young. In comparison, a peak number of 3,542 active double-crested cormorant nests were observed on the Astoria-Megler Bridge on June 4, 2019, more than double the number seen in previous year (Scalfani 2020).

B.2.2.2 Smolt Predation Rates by East Sand Island Cormorants

Before 2016, most double-crested cormorants in the estuary nested on East Sand Island and researchers were able to estimate predation rates for the estuary as a whole based on PIT-tag recoveries at that location. Since 2016, however, large numbers of cormorants have abandoned East Sand Island and moved to the Astoria–Megler Bridge and other locations upstream for much of the breeding season (MacDonald 2017, Turecek et al. 2019). Estimates of smolt consumption calculated by the researchers for 2016 through 2018 therefore must be considered underestimates because cormorants spent little time on the island during the peak smolt outmigration (Evans et al. 2018a). Although Evans and Payton (2020a) show predation rates by cormorants on East Sand Island during 2016 to 2018 that are lower (and statistically significant) compared to those before management actions were initiated (Table B-2), the post-management estimate of impact may be less than half that of the large number of birds foraging from the Astoria-Megler Bridge.[4]

[4] Collis et al. (2002) observed that double-crested cormorants nesting on the Astoria-Megler Bridge were more likely to feed in the upstream areas used by those nesting on Rice Island in 1997 to 1998. Those cormorants consumed three times more salmonids than those on East Sand Island because their foraging range did not overlap or overlapped to a lesser degree with marine fishes such as herring, surfperch, and flounder in the lower estuary. Cormorants nesting on the Astoria-Megler Bridge, about midway between Rice and East Sand Islands, may still be able to take advantage of marine forage fish, but to an unquantified amount.

Table B-2. Average annual predation rates (with 95 percent credible intervals) by double-crested cormorants nesting on East Sand Island prior to (Pre) and following (Post) implementation of management actions. Management actions included lethal take of eggs and adults and passive dissuasion during Phase I and egg take and passive dissuasion (only) during Phase II. An asterisks (*) indicates statistically credible differences between management periods for a salmonid species. NA denotes that estimates were not available during that time period Source: Evans and Payton (2020a).

Salmonid ESU/DPS	Pre	Post, Phase I[a]	Post, Phase II[a]
	2003-2014	2015-2017	2018
SR sockeye salmon[b]	4.2% (3.3-5.3)	2.4% (1.4-4.0)	0.9% (0.4-1.9)*
SR spr/sum Chinook salmon	4.6% (4.1-5.3)	6.8% (5.3-9.4)	0.5% (0.3-0.8)*
UCR spr Chinook salmon	3.8% (3.2-4.6)	4.1% (3.2-5.8)	0.6% (0.3-1.2)*
SR fall Chinook salmon	2.7% (2.3-3.2)	3.7% (2.6-5.4)	0.9% (0.5-1.6)*
SR steelhead	7.2% (6.3-8.5)	6.8% (5.3-9.4)	0.5% (0.3-0.9)*
UCR steelhead	6.3% (5.5-7.2)	5.8% (4.5-8.1)	0.7% (0.4-1.4)*
MCR steelhead[c]	7.5% (6.3-9.3)	5.4% (4.0-7.7)	0.4% (0.1-1.0)*
LCR Chinook salmon[d]	27.5% (24.3-30.7)	8.7% (6.2-12.1)*	7.3 (4.8-11.6)*
LCR steelhead[e]	5.4% (4.5-6.3)	5.0% (3.7-6.9)	0.6% (0.3-1.0)*
LCR coho salmon[f]	15.0% (12.2-18.1)	0.2% (0-0.7)*	0.3% (0.1-0.8)*
CR chum salmon	NA	NA	NA
UWR Chinook salmon[g]	1.8% (1.3-2.6)	1.4% (0.6-2.9)	NA
UWR steelhead	NA	NA	NA

[a] Predation rate estimates during the post-management periods are minimum estimates due to en masse dispersal or redistribution events or because colony formation was delayed until after the peak smolt outmigration period (Evans and Payton 2020a).

[b] Predation rate estimates were not available in 2003 to 2008 and in 2016 to 2017.

[c] Predation rate estimates were not available in 2003 to 2006 and in 2017.

[d] Predation rate estimates were not available in 2003 to 2006.

[e] Predation rate estimates were not available in 2003 to 2006.

[f] Predation rate estimates were not available in 2003 to 2006.

[g] Predation rate estimates were not available in 2003 to 2006 and in 2012 to 2015.

[h] Predation rate estimates were not available in 2003 to 2006 and in 2017.

B.2.2.1.1 Cormorant Predation on Lower Columbia River Chinook and Coho Salmon and Steelhead

Sebring et al. (2013) estimated predation rates by double-crested cormorants on PIT-tagged subyearling hatchery Chinook salmon from the LCR Chinook salmon ESU during 2002 to 2010. Based on PIT-tag recoveries from East Sand Island, minimum predation rates on these hatchery smolts averaged 10 percent. Lyons et al. (2014) estimated an average predation rate of 26 percent on LCR Chinook salmon during 2007 to 2010. Predation rates differed by rearing type, averaging 29 percent on hatchery-origin Chinook salmon and 11 percent on natural-origin Chinook salmon.

Sebring et al. (2012) estimated a 10 percent minimum predation rate on PIT-tagged hatchery-origin LCR coho salmon by cormorants nesting at East Sand Island in 2010. Lyons et al. (2014) estimated an average predation rate of 28 percent on the LCR coho salmon ESU by this colony during 2007 to 2010, weighting estimates by the relative abundances of hatchery- and natural-origin fish originating upstream and downstream of Bonneville Dam. Predation rates differed by rearing type, averaging 30 percent on hatchery-origin and 10 percent on natural-origin coho salmon.

More recently, Evans and Payton (2020a) estimated double-crested cormorant predation rates for LCR Chinook salmon, LCR coho salmon, and LCR steelhead using the same PIT tag analyses (i.e., including adjustments for deposition rates) they have performed in the past for interior Columbia salmonids (see Table B-2). The estimate for cormorant predation on LCR Chinook salmon for the pre-management period (27.5 percent) is much higher than the minimum predation rate (10 percent) described in Sebring et al. (2013), but similar to that in Lyons et al. (2014), 28 percent. Evans and Payton (2020a) reported somewhat lower cormorant predation rates on LCR coho salmon: 15.0 percent during the pre-management period and <1 percent during each of the post-management periods. The pattern for LCR steelhead differed—an average predation rate of 5.4 percent by cormorants on East Sand Island before the start of colony management and 5.0 and 0.6 percent during the Phase I and Phase II post-management periods, respectively. As described above for the interior species, due to the movement of large numbers of cormorants from East Sand Island to the Astoria–Megler Bridge beginning in 2016, data for the pre- and post-management periods are not directly comparable.

B.2.2.3 Summary—Impacts of Double-crested Cormorants in the Columbia River Estuary

The movement of double-crested cormorants from the East Sand Island colony to the Astoria-Megler Bridge in 2016 to 2018 indicates that this species' response to colony management activities and frequent disturbance by bald eagles, often followed by gulls taking eggs and chicks, remains in flux. The terrain modification action in Phase II of the management plan was completed before the 2019 nesting season to ensure that this colony does not exceed the management plan objective of no more than 5,380-5,939 nesting pairs. At the same time, the number of birds nesting on the Astoria–Megler Bridge has continued to grow so that an estimated 6,319 nesting pairs (including 4,103 on East Sand Island and 1,736 on the Astoria-Megler Bridge) were in the estuary during 2018 and up to 4,666 (including 399 on East Sand Island and 3,542 on the Astoria Megler Bridge) in 2019 (Scalfani 2020). As a result of these movements to upstream sites, the predation rates shown in Table B-2, which are based on PIT tag collections from East Sand Island, underestimate double-crested cormorant predation pressure in the estuary as a whole.

B.2.3 Summary—Effects of Avian Predator Colonies in the Columbia River Estuary

The nesting attempts by up to 1,000 terns on East Sand Island in the last few years indicate that these birds are moving around the estuary in response to habitat reduction on East Sand Island. The Corps has increased dissuasion efforts to keep prospecting terns from nesting on Rice Island and, at the same time, the numbers of nesting pairs on East Sand Island have declined. These are indications that the tern management plan, in combination with predation pressure from bald eagles and gulls, has been successful at reducing the number of terns in the estuary and thus smolt predation. Continued monitoring indicates that this pattern is continuing. If it does not, additional management actions may be needed to protect listed salmonids. The movement of cormorants from East Sand Island to nesting sites farther upstream in the estuary over the same period, whether as a result of bald eagle pressure or management actions, indicates that implementation of the management plan may not have reduced predation rates on listed salmonids.

B.3 Effects of Avian Predator Colonies on the Interior Columbia Plateau

B.3.1 Management Activities at Inland Caspian Tern Colonies

Predation on salmonids by piscivorous waterbirds nesting in the Columbia basin upstream of Bonneville Dam (i.e., interior Columbia plateau) became a concern when colonies became established at Crescent Island in McNary Reservoir and on Goose Island in Potholes Reservoir. Roby et al. (2011) estimated total predation on salmonids at Crescent Island during 2004 to 2009 of 330,000 to 500,000 smolts per year. Annual predation rates on UCR steelhead by terns nesting on Goose Island (Potholes Reservoir) averaged 15.7 percent during 2007 to 2013 (Collis et al. 2018). As a result of these impacts, NMFS required the Corps and Reclamation to develop an Inland Avian Predation Management Plan (IAPMP) in RPA action 47.

The objective of the IAPMP is to reduce predation on ESA-listed salmonids by Caspian terns nesting at Goose and Crescent Islands while taking actions to prevent terns from forming new colonies and/or expanding existing colonies where feasible (USACE 2014). In general, the IAPMP aims to reduce predation on interior Columbia basin salmonids to less than 2 percent for each listed ESU/DPS per tern colony per year. The primary management goal during the first phase was to fully dissuade terns from nesting on Goose Island with a long term goal of reducing the colony to less than about 40 breeding pairs (to meet the <2 percent predation rate objective). During the first year of implementation (2014), The Corps set up passive dissuasion (ropes and flagging) and conducted active hazing. However, 156 pairs nested on a nearby islet called Northwest Rocks (Roby et al. 2015). Terns also tried to nest at other colony sites they had used previously (Crescent Island in McNary Reservoir, the Blalock Islands in John Day Reservoir, Twinning Island in Banks Lake, and Harper Island in Sprague Lake) and a small island in Lenore Lake. Only the colonies at Crescent Island and the Blalock Islands succeeded in raising young. The colony on Crescent Island was the largest in the interior Columbia plateau region that year (474 breeding pairs).

The second phase of the IAPMP called for development of suitable alternative Caspian tern nesting habitat in areas where predation on ESA-listed species would be lower before dissuading terns from Crescent Island. Similar to efforts on Goose Island, the short-term goal was to dissuade terns from nesting with a long-term goal of less than about 40 nesting pairs (to achieve the less than 2 percent predation rate objective) (USACE 2014). The Corps identified a potential site at Don Edwards San Francisco Bay National Wildlife Refuge and modified this area for tern nesting during winter 2014 to 2015, so the Action Agencies were able to begin dissuading terns from Crescent Island during the 2015 breeding season. Passive dissuasion. Hazing successfully prevented nesting on Crescent Island and most of the nesting at Goose Island. However, the number of terns at the Blalock Islands was ten times higher in 2015 than the year before and resightings of colored leg-bands indicated that large numbers had moved there from Crescent Island (many of these individuals nested at the Blalock Islands again in 2016). Terns also came to the interior plateau from East Sand Island in the estuary, and from additional Corps'-constructed colony sites in southeastern Oregon and northeastern California in 2015 when those areas experienced severe drought.

Terns displaced from Crescent Island continued to relocate to the unmanaged colony sites at the Blalock Islands and to a limited degree (i.e., below the 40 pairs per colony threshold) at Badger Island in 2017 (Collis et al. 2018). Overall, the number of pairs of Caspian terns at each colony in the interior Columbia plateau region during 2017 represented a 19 percent decline compared to the pre-management period (Figure B-1). Numbers of pairs were the same or lower at these colonies in 2018 when an estimated 491 breeding pairs of Caspian terns nested at four breeding colonies (Blalock Island, Badger Island, Harper Island in Sprague Lake, and an unnamed island in Lenore Lake; Collis et al. 2019). This represented a 44 percent decline in the size of the breeding population compared pre-management average (2005 to 2013) and a 28 percent decline when compared to the management period (2014 to 2017).

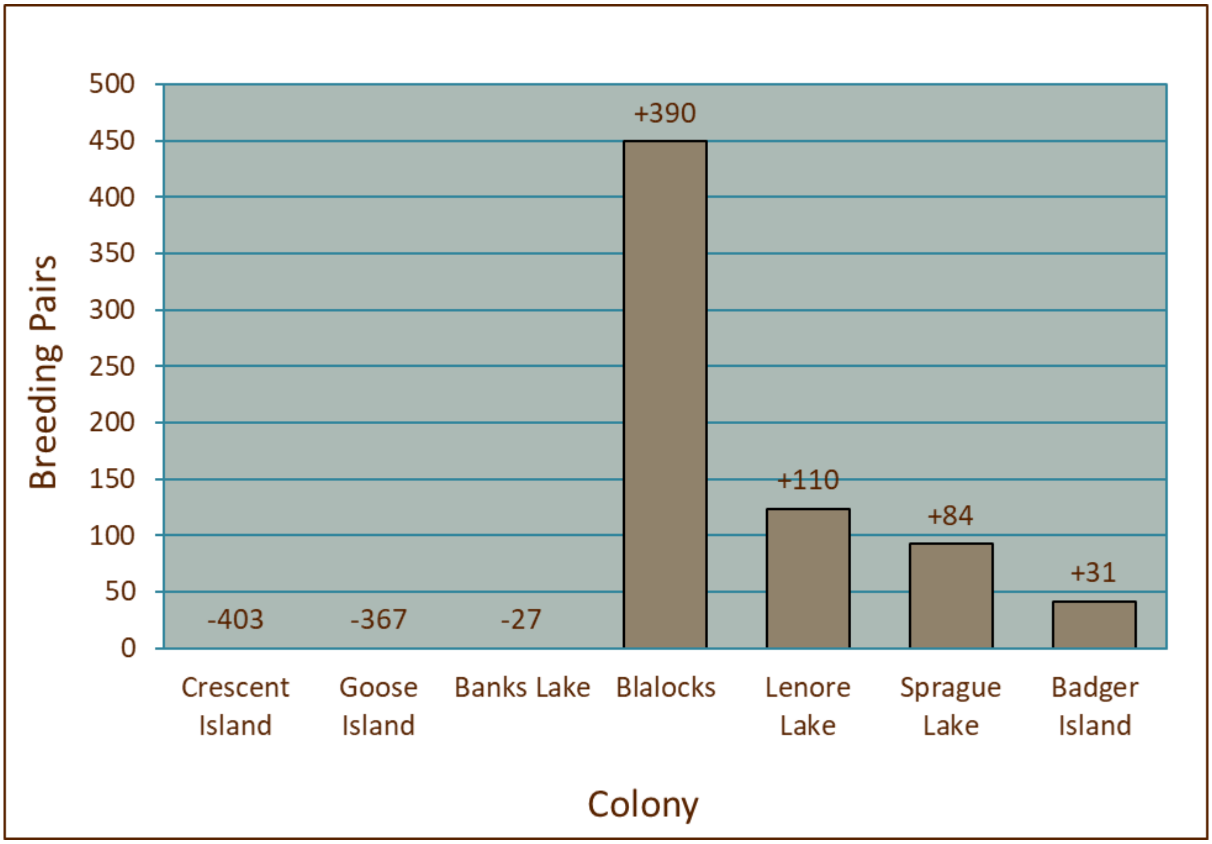

Figure B-1. Sizes of Caspian tern nesting colonies (numbers of breeding pairs) in the interior Columbia plateau region during the 2017 breeding season. The number over each bar indicates the change in colony size in 2017 compared to the average colony size before tern management (2005 to 2013). Source: Collis et al. (2018).

B.3.2 Salmonid Predation Rates at Interior Columbia Plateau Tern Colonies

In 2017, the goal of the IAPMP to reduce ESU/DPS-specific predation rates to less than 2 percent was achieved at Goose Island for the third consecutive year and Crescent Island for the fourth (Collis et al. 2019). As a result, Caspian tern predation on UCR steelhead has declined from about 2 to 15 percent at these three managed colonies (Table B-3). However, predation rates on other ESA-listed salmonids (especially SR sockeye salmon and SR steelhead) by terns on the Blalock Islands have been higher since colony management began at Goose and Crescent Islands (Table B-4).

Table B-3. Average annual predation rates by Caspian terns at managed colonies in the interior Columbia plateau region prior to (Pre) and following (Post) implementation of management actions. Only ESA-listed salmonids migrating from the Snake River (SR) and Upper Columbia River (UCR), including steelhead, sockeye salmon, and spring (spr), summer (sum), and fall run Chinook salmon, are within foraging distance of these colonies. NC denotes that no colony existed during a time period. Management actions were implemented on Goose Island in Potholes Reservoir during 2014 to 2018, on an unnamed island in northeastern Pothole Reservoir in 2017 to 2018, and on Crescent Island during 2015 to 2018. Source: Evans and Payton (2020a)

ESU/DPS	Goose Island			North Potholes Island			Crescent Island		
	Pre 2007-2013	**Post 2014-2019**	**Last 3 Yrs 2017-2019**	**Pre 2007-2013**	**Post 2016**	**Last 3 Yrs 2017-2019**	**Pre 2007-2014**	**Post 2015-2019**	**Last 3 Yrs 2017-2019**
SR Sockeye	<0.1%	<0.1%	<0.1%	NC	<0.1%	<0.1%	1.5% (1.2-2.0)	<0.1%	<0.1%
SR spr/sum Chinook	<0.1%	<0.1%	<0.1%	NC	<0.1%	<0.1%	0.8% (0.7-1.0)	<0.1%	<0.1%
UCR spr Chinook	2.5% (1.7-3.6)	<0.1%	<0.1%	NC	0.1% (0.1-0.3)	<0.1%	0.5% (0.3-0.9)	<0.1%	<0.1%
SR fall Chinook	<0.1%	<0.1%	<0.1%	NC	<0.1%	<0.1%	1.0% (0.9-1.2)	<0.1%	<0.1%
SR steelhead	<0.1%	<0.1%	<0.1%	NC	<0.1%	<0.1%	4.5% (4.1-5.1)	<0.1%	<0.1%
UCR steelhead	15.7% (14.1-18.9)	<0.1%	<0.1%	NC	4.1% (2.9-6.3)	<0.1%	2.5% (2.2-2.9)	<0.1%	<0.1%

Table B-4. Average annual predation rates (95% credible intervals) by Caspian terns at the Blalock Islands, and unmanaged colony, prior to (Pre) and following (Post) implementation of management activities at Goose and Crescent Islands. Impacts are shown for ESA-listed salmonids migrating from the Snake River (SR) and Upper Columbia River (UCR), including steelhead, sockeye salmon, and spring (spr), summer (sum), and fall Chinook salmon runs. Source: Evans and Payton (2020a)

ESU/DPS	Blalock Islands		
	Pre 2007-2013	Post 2014-2019	Last 3 Years 2017-2019
SR sockeye salmon	0.2% (0.1-0.4)	1.6% (1.0-2.5)	1.8% (0.7-4.0)
SR spr/sum Chinook salmon	0.1% (0.1-0.2)	0.7% (0.5-0.9)	0.6% (0.4-0.9)
UCR spr Chinook salmon	<0.1%	0.6% (0.5-0.9)	0.8% (0.5-1.3)
SR fall Chinook salmon	<0.1%	0.7% (0.6-1.1)	0.9% (0.6-1.4)
SR steelhead	0.5% (0.4-0.9)	3.7% (3.1-4.6)	3.1% (2.4-4.1)
UCR steelhead	0.5% (0.3-0.7)	4.3% (3.5-5.6)	4.5% (3.4-6.1)

B.3.3 Gull Colonies on the Interior Columbia Plateau

When the IAPMP (USACE 2014) was developed, estimates of salmonid predation by gulls nesting in the interior Columbia plateau region did not exceed 2 percent per listed ESU/DPS per colony per year (Table B-5). The largest impact by California and ring-billed gulls (*Larus californicus* and *L. delawarensis*, respectively) was from the colony nesting at Miller Rocks, a group of rock outcroppings and small islands in The Dalles Reservoir. The Corps concluded that, in comparison to Caspian terns nesting at Goose and Crescent Islands, the benefits to ESA-listed salmonids through reductions in predation by avian predators, such as gulls nesting on Miller Rocks, would be substantially lower (Lyons et al. 2011).

Table B-5. Average annual predation rates on ESA-listed Snake River (SR) and Upper Columbia River (UCR) salmonids by California and ring-billed gulls at Miller Rocks, The Dalles Reservoir, 2007 to 2010, adjusted to account for the fraction of each salmonid species transported around the interior Columbia plateau waterbird colonies as part of the Corps' juvenile salmonid transportation program. Sources: Lyons et al. (2011), USACE (2014).

Chinook			Sockeye	Steelhead	
SR spr/sum	SR fall	UCR spr	SR	SR	UCR
0.3%	0.3%	0.4%	0.6%	1.2%	1.6%

While implementing the IAPMP, the Corps' made an effort to prevent nesting by California and ring-billed gulls on Goose and Crescent Islands. This decision was based on the theory that gulls attract prospecting Caspian terns and, thus, could limit the efficacy of dissuasion efforts (USACE 2014; Roby et al. 2016). The effort was partially successful, with gulls dispersing from Crescent Island to add to numbers at the colonies on Island 20 (McNary Reservoir), Miller Rocks (The Dalles Reservoir), and the Central Blalock Islands (John Day Reservoir) in 2015 (the gull colony on Goose Island has remained relatively stable in recent years) (Collis et al. 2018). Gull predation rates, like those of terns, were generally higher for juvenile steelhead than for salmon (Table B-6).[9]

[9] Due to improvements in estimation methods, the predation rates in Table B-6 are more accurate than those in Table B-5.

Table B-6. Average annual predation rates (95 percent credible intervals) by unmanaged California and ring-billed gulls (LAXX) colonies on Island 20 and Badger Island (McNary Reservoir) on PIT-tagged Snake River (SR) and Upper Columbia River (UCR) salmonids. Source: Evans and Payton (2020a).

ESU/DPS	Island 20 2013-2019	Badger Is. 2015-2019	Crescent Is. 2007-2014	Blalock Is. 2013-2019	Miller Rocks 2007-2019
SR sockeye	0.9% (0.3-1.7)	2.7% (1.2-4.8)	2.2% (1.3-3.2)	2.0% (1.0-3.0)	6.2% (4.8-7.7)
SR spr/sum Chinook	0.2% (0.1-0.3)	0.5% (0.3-0.6)	1.0% (0.8-1.2)	0.2% (0.1-0.2)	1.2% (1.1-1.4)
UCR spr Chinook	0.5% (0.1-1.2)	1.6% (0.7-2.9)	1.2% (0.4-2.3)	0.4% (0.2-0.6)	2.1% (1.7-2.4)
SR fall Chinook	0.2% (0.1-0.4)	0.9% (0.5-1.4)	0.6% (0.4-0.9)	0.4% (0.3-0.6)	2.0% (1.8-2.4)
SR steelhead	1.6% (1.2-1.9)	3.3% (2.5-4.3)	4.8% (4.1-5.6)	2.4% (2.0-3.0)	7.2% (6.5-8.1)
UCR steelhead	4.1% (3.3-4.9)	5.0% (3.5-6.9)	5.8% (5.0-6.9)	3.9% (3.0-4.8)	8.2% (6.9-9.3)

The following average annual predation rates have exceeded 2 percent per listed ESU/DPS per gull colony per year:

- Island 20 – UCR steelhead;
- Badger Island – SR sockeye salmon, SR steelhead, and UCR steelhead;
- Crescent Island – SR sockeye salmon, SR steelhead and UCR steelhead;
- Blalock Islands – SR steelhead and UCR steelhead; and
- Miller Rocks – SR sockeye salmon, UCR spring Chinook salmon, SR steelhead, and UCR steelhead.

Consumption rates by gulls from colonies in the interior Columbia plateau region during 2015 were significantly higher than those observed at the same colonies in previous years, with a roughly two- to five-fold increase in some cases (Roby et al. 2016). Consumption rates for gulls nesting on Miller Rocks were the highest of any gull colony evaluated.

Further research is needed to understand whether gulls disproportionately consume weak or compromised smolts, especially near dams, or prey on fish from the general outmigrant population. In either case, smolt predation rates at certain gull colonies have continued to be some of the highest associated with any piscivorous waterbird colony in the interior Columbia Plateau region since multi-predator species studies were initiated in 2007. Management of gull predation is not addressed in the current avian predation management plans for the Columbia plateau or the estuary.

B.3.4 Summary—Impacts of Avian Predator Colonies on the Interior Columbia Plateau

As discussed in Collis et al. (2019), management actions to eliminate breeding colonies of Caspian terns on Goose Island in Potholes Reservoir and on Crescent Island in McNary Reservoir—formerly the largest breeding colonies for the species in the interior Columbia plateau region—were successful in 2017 and 2018. As a result, predation on juvenile salmonids by Caspian terns nesting at these two sites was effectively eliminated. Overall, numbers of breeding Caspian terns on the interior Columbia plateau decreased by 44 percent from pre-management levels due to the management of colonies on Goose and Crescent Islands through 2018. However, resightings of banded Caspian terns in previous years show that most terns that were displaced from Goose and Crescent Islands have remained in the region and many have tried to nest at unmanaged colony sites. Most notable has been the post-management increase in the size of the formerly small breeding colony in the Blalock Islands. Caspian terns nesting in the Blalock Islands during 2015 to 2018 consumed sufficient numbers of juvenile salmonids to at least partially off-set reductions in smolt consumption due to tern management at Goose and Crescent Islands. Based on results during the first five years of implementation of the IAPMP, tern predation rates in the interior Columbia are decreasing, but it appears that the over-all goal of the management plan to reduce predation rates to less than 2 percent per tern colony on ESA-listed ESU/DPS per year will not be fully realized until nesting habitat is reduced at the currently unmanaged colony sites, especially in the Blalock Islands. Under the 2020 proposed action (BPA et al. 2020), the Action Agencies will increase the normal forebay operating range at John Day Dam by 2 feet during April 10 through June 1 or June 15 to deter Caspian terns from nesting at the Blalock Islands Complex. The purpose of this operation is to reduce predation pressure on spring migrating, ESA-listed juvenile salmon and steelhead by deterring Caspian terns from nesting in the Blalock Islands Complex during this period.

In addition, average annual predation rates by gulls have exceeded those at tern colonies on the interior Columbia plateau, at least for SR and UCR steelhead. Reductions in gull predation rates at the colony level were considered not warranted when the IAPMP was developed and there are no regional plans to manage these colonies.

B.4 Is Caspian Tern or Double-crested Cormorant Predation Additive or Compensatory?

An unstated assumption in many predator control programs is that reducing predation during one life stage increases the survival of prey over a longer portion of its life cycle. In the current context, this would suggest that ensuring that fewer smolts are eaten by Caspian terns or double-crested cormorants during their outmigration would increase the number of adult returns (e.g., as measured by SARs). If so, avian predation would be considered an “additive” source of mortality. Alternatively, if the smolts “saved” from predation succumbed to other sources of mortality such as predators in the ocean, disease, or starvation, then avian predation would be considered a “compensatory” source of mortality.

The completely additive and completely compensatory hypotheses are illustrated in the left and right panels, respectively, of Figure B-2 (adapted by Evans et al. 2019b from Anderson and Burnham 1976 and Sandercock et al. 2011). The first graph shows an additive relationship between survival and predation rate (slope = -1). If tern and/or cormorant predation is a completely additive source of mortality for Columbia Basin salmonids, smolt survival will decrease linearly as tern or cormorant predation increases. However, if tern and/or cormorant predation is completely compensatory, then smolt survival would remain constant as predation by terns or cormorants increases up to a critical threshold, above which smolt survival would decline.

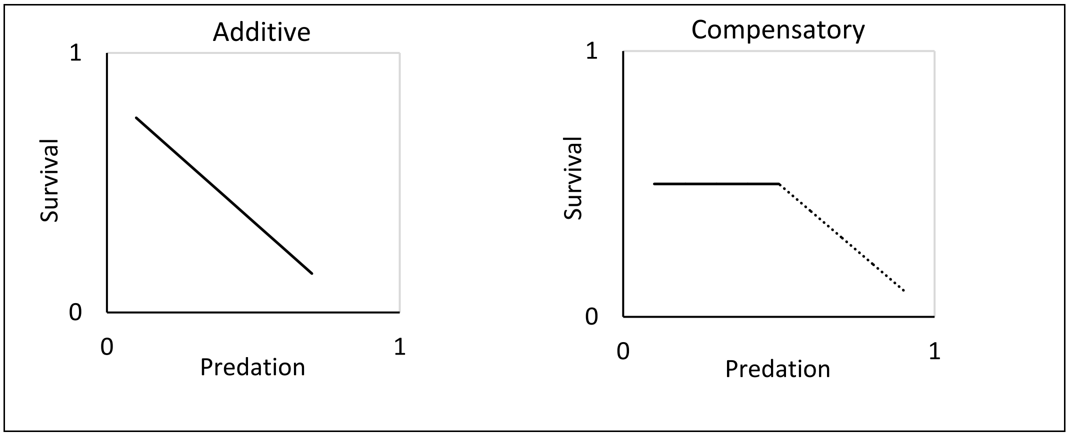

Figure B-2. Graphical representation of the completely additive and compensatory hypotheses for the effects of avian predation on the survival of salmonid populations to adulthood, adapted by Evans et al. (2019b) from Anderson and Burnham (1976) and Sandercock et al. (2011).

In recent years, researchers in the Columbia basin have asked if tern or cormorant predation is additive, or whether it is compensatory to some degree. If the latter, reducing predation rates by culling birds or reducing colony sizes may not translate into an increase in survival to adulthood. There is evidence that, at least for steelhead, fish condition, size, and rearing history may affect the vulnerability of fish to avian predation (Hostetter et al. 2012) and it is likely that predation losses to avian predators is somewhat compensatory due to these vulnerabilities. NMFS can use information on degree of compensation to assess whether the Action Agencies' avian predator control programs are affecting the number of returning adults. In the following sections, we review the modeling studies by Haeseker et al. (2020) and Evans et al. (2019b) that describe these relationships.

B.4.1 Estimating Correlations between Avian Predation Rates and Adult Returns for SRB Steelhead

Haeseker et al. (2020) applied a random effects model to a 16-year mark-recapture-recovery data set to assess whether predation by Caspian terns and double-crested cormorants on SRB steelhead smolts constituted an additive or compensatory source of mortality. Haeseker et al. (2020) state that a negative correlation between the avian predation and survival processes would be consistent with the hypothesis that avian predation is having an additive effect on survival. They found that, for both colonies, the estimated correlation between the predation rate and survival rate of steelhead was near zero, claiming that this indicates that mortality due to avian predation is compensatory–that smolts not eaten by terns and cormorants nesting on East Sand Island would have died anyway due to other causes.

Fish Management staff at the Columbia River Inter-Tribal Fish Commission have reviewed this paper, identifying several methodological concerns that weaken the results and cautioning against acceptance of the conclusions in this paper. The concerns expressed in Skiles (2020) are summarized here:

- **Ocean survival**
    - The authors assumed an annual survival rate of 0.8 for steelhead that remain in the ocean from the first to second year, but this value, which was published for salmon in Ricker (1976), may not be appropriate for steelhead.
    - Ocean conditions have changed dramatically since 1976 and it is unlikely that the conditions that resulted in a survival rate of 0.8 in 1976 are the same as in the period of this study (2000 to 2015 outmigrants and their first year returns).
    - The authors should have conducted a sensitivity analysis to their assumption that first to second year ocean survival is constant because, although most of the variation in ocean survival does occur in the first year, it is not true that first to second year survival never changes.
- **Covariates for the survival model**
    - The authors "evaluated 4 candidate environmental indices previously identified in other studies as being associated with salmonid survival," but only exploring models with 4 potential covariates to explain survival is too narrow for this statistical investigation. Other potential covariates would include fish length, avian colony size, and forage fish abundance.
    - Since all fish in this study were detected at Bonneville Dam as juveniles, a term indicating arrival day at Bonneville Dam was used as a covariate. This variable acts as a proxy for other covariates (e.g., spill percentage, temperature, and degree of smoltification) that change throughout the migration season. However, other studies that have used arrival day as a covariate also include non-linear effects of this variable by inclusion of a quadratic term. It is likely that inclusion of a quadratic term would have explained more variation in survival, but also may have diminished the significance of other covariates that were found to be statistically significant.
- **Modeling survival in the covariate model**
    - The model likely underestimates the true variation in survival by assuming that the survival term is constant within cohorts and across years. The authors built a multivariate normal model for survival and predation with a standard covariance matrix, but the right hand side of this equation is missing several terms. A true "full model" would take a more complicated form and would include additive effects of yearly and weekly cohorts and potentially multiplicative effects of year and cohorts.
- **Hypothesis test of the correlation coefficient**
    - The authors built a multivariate model with a standard covariance matrix. They interpreted estimates of the correlation coefficient that were near zero with credible intervals that overlapped zero as indicating compensatory mortality, and

negative estimates of the correlation coefficient with credible intervals that did not overlap zero as indicating additive mortality. However, the logic of this interpretation is not correct. The authors failed to reject the null hypothesis that mortality is compensatory as the estimated confidence intervals for the correlation coefficient included zero, but from a statistical hypothesis testing framework this does not imply that mortality is compensatory.

- **Assessing additive and compensatory mortality is difficult at this life stage**
  - The authors should have given more attention to the idea that it is very difficult to determine whether avian mortality is additive or compensatory given that this source of mortality is small compared to all other sources of mortality that occur throughout the life-cycle of steelhead.
  - The authors conducted their study over multiple years of the steelhead life-cycle. Conducting this study over a shorter period (i.e., for individual years) might have resulted in different conclusions.
  - A power analysis could have been conducted to determine what sample sizes were necessary to detect additive mortality if it indeed existed. Or, a simulation analysis could have been conducted where additive mortality was assumed in the simulated data and the models used by the authors evaluated to determine if they could detect this effect.

Although NMFS has not yet reviewed the Haeseker et al. (2020) paper to this extent, the concerns described in Skiles (2020) appear valid. We expect that this paper will receive additional regional review in the context of adaptive management for avian predation management at the East Sand Island and inland colony sites in the coming year.

B.4.2 Joint Mortality and Survival Model

Payton et al. (2020) also studied the relationship between avian predation and SARs, in this case using the Joint Mortality and Survival Model described in Payton et al. (2019). In contrast to Haeseker et al. (2020), these authors found "strong evidence that Caspian tern predation was an additive source of mortality for all spatial scales, years [2008 to 2015], and life-stages (smolt, SAR) evaluated." This modeling framework looks at the effect of tern predation at multiple colonies rather than just the single large colony on East Sand Island as in Haeseker et al. (2020). Enlarging the scope of the study to colonies above Bonneville Dam, some of which have also been subject to management measures, probably increased the ratio of the signal of avian predation to that of other factors that affect the likelihood of adult returns. There are several other important differences between this approach and the one taken in Haeseker et al. (2020). In addition to looking at effects on UCR instead of SRB steelhead, Payton et al. (2020) analyzed the degree of additivity (or compensation) for each annual cohort of outmigrants rather than across a multiyear study period. Payton et al. (2020) reported that Caspian tern predation may have been a partially additive source of mortality to (Figure 4 in Payton et al. 2020). Although the statistical model used in this study was reviewed before publication in the journal Environmental and Ecological Statistics, our understanding of its implications for adaptive management will also benefit from regional discussion and review.

B.4.3 Compensatory versus Additive Mortality in the 2008/2010/2014 FCRPS Biological Opinions and 2019 CRS Biological Opinion

The RPA developed for the 2008 FCRPS biological opinion and its 2010 and 2014 supplements employed multiple measures to improve the survival of ESA-listed salmonids. This included efforts to improve hydrosystem structures and operations, tributary and estuary habitat quality, and hatchery practices, and reduce avian, fish, and pinniped predation. NMFS did not quantitatively assume any compensatory mortality in assessing the benefits of predation management as applied to Caspian terns in the 2008 FCRPS biological opinion and in the 2014 FCRPS biological opinion, stated there was no clear indication that the case would be different, or substantial, for predation by double-crested cormorants.

As described above, the approaches taken more recently by modelers investigating the degree to which Caspian tern predation in the Columbia basin may be additive versus compensatory vary widely. They require more regional review before we can apply their findings to fisheries management or incorporate them into life cycle models such as those used in the 2020 opinion for SR spring/summer Chinook salmon and UCR spring Chinook salmon. The Action Agencies propose to continue implementing the avian predation management plans described in sections B.2 and B.3, maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island and continuing to dissuade terns from nesting on Goose and Crescent Islands on the interior Columbia plateau (BPA et al. 2020, USACE et al. 2020). Thus, we expect that any reduced avian predation rates achieved under the 2008 FCRPS biological opinion and associated RPA will continue. Although work remains, we expect that at least some of the predation that is occurring is additive and contributes to increased SARs.

B.5 Summary—Avian Predation Management in the Columbia Basin

The region's success in improving the survival of juvenile salmonids by managing the size of avian predator colonies is uncertain, but data from the 2018 and 2019 field seasons indicate that numbers of terns in the Columbia basin and their smolt predation rates have decreased (Harper and Collis 2018, Roby et al. 2019, Turecek et al. 2019). There is uncertainty because many Caspian terns moved to nearby locations in recent years rather than leaving the Columbia Basin. However, the Corps has been successful at keeping terns from nesting on Rice, Miller Sands, and Pillar Islands in 2018 and 2019 and the number of terns on East Sand Island has been much lower than any other year since 2000, indicating an overall reduction in the number in the estuary. Nevertheless, the estimated size of the East Sand Island colony in 2018 was substantially larger than the target colony size of up to 4,375 breeding pairs. On the interior Columbia plateau, the long term success of tern management efforts will depend on whether the Action Agencies successfully maintain the passive dissuasion established under the Inland Avian Predation Management Plan. With respect to double-crested cormorants, the number nesting on East Sand Island has declined, but large numbers have moved to the Astoria-Megler Bridge where per capita predation rates on salmonids is likely to be even higher than before colony management.

The 2020 Avian Predation Synthesis Report will help the adaptive management teams consider whether the Action Agencies or other regional parties should change their implementation strategies, including whether new measures should be assessed that could further reduce predation pressure. As discussed in Section B.4.3, an important question in evaluating the success of these programs is whether avian predation is an additive or compensatory source of mortality. That is, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality, or are many of the smolts eaten by birds destined to die before returning as adults regardless of the level of avian predation? Haeseker et al. (2020) and Payton et al. (2020) have modeled these relationships, but these papers need more review. NMFS' position in this biological opinion is that, given the magnitude of bird predation on smolts, especially steelhead, in the Columbia Basin, it is likely that some of the individuals consumed by birds could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that the current and potential future efforts to limit the size of these tern and cormorant colonies are contributing to increased SARs for some populations of the listed ESUs/DPSs.

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Appendix C - Life-cycle Model Outputs

Note: This appendix contains modelling outputs in tabular form for abundance, QET50, and QET30 for all populations modelled. More detailed description of the model outputs, including references, are presented in the main document. See Section 2.2.3.1.12 Life-Cycle Models (SR spring/summer Chinook salmon), Section 2.5.3.1.12 Life-Cycle Modeling (SR fall Chinook salmon), and Section 2.6.3.1.12 Life-Cycle Modeling (UCR spring-run Chinook salmon). A complete description of the models is presented in Zabel 2020 and Perry 2020.

C.1 Abundance

A time period of 24 years forward from 2020 was selected as a reasonable timeframe to assess parameters generated by the models, including the geomean spawner abundance and the quasi-extinction risk threshold (QET). The period of 24 years includes approximately 6 generations of fish which would have experienced the proposed action as juveniles and returned to their natal streams as adults.

The abundances presented are the geomean spawner abundance for years 15 through 24 of the 24-year period of analysis. As noted, they represent either only natural-origin spawners, or natural- and hatchery-origin spawners. In the case of fall Chinook salmon, the abundance represents only female spawners. For all other populations modeled, the number represents both male and female spawners.

The QET is an estimate of the probability of a population reaching abundance levels for four consecutive years that may be too small to effectively reproduce—especially in larger basins where spawning adults might have more difficulty finding one another. Small populations are also more at risk from demographic stochasticity, genetic processes, and environmental variability. Because the exact number at which this condition occurs for Chinook salmon populations is unknown (and is likely variable due to a number of factors), past biological opinions (e.g., NMFS 2008a) provided QET projections for 50, 30, 10, and 1 individual. In this opinion, NMFS presents QET projections for 30 and 50 adults (for four consecutive years in the projected abundance estimates over the next 24 years) as a useful means of illustrating differences resulting from factors affecting the abundance and productivity of the modeled populations.

C.2 Climate Modelling

To account for anthropogenic carbon emissions, we extracted trends from global climate model (GCM) projections of RCP4.5 and RCP8.5 emission scenarios. The climate scenarios were modelled using the ensemble approach, as advocated by the Intergovernmental Panel on Climate Change (IPCC 2014). This approach addresses uncertainty in model assumptions by using as many different models as possible. There are 26 GCMs available for each emissions scenario from Coupled Model Intercomparison Project CMIP5, available from NOAA's Earth Systems Research Laboratory (Alexander et al. 2018). Scientists at the University of Washington downscaled output from 10 of those GCMs using multiple downscaling methods, and processed the output through four different hydrological models to produce 80 different time series for naturalized flow across the Columbia River Basin (RMJOC 2018, Chegwidden et al. 2019). Different GCMs and hydrological models projected more or less change in a given environmental variable, reflecting differences in model characteristics. To capture this range of environmental projections, we modeled population responses to the lower quartile, mean, and upper quartile time series available for each emissions scenario. Thus we represented model uncertainty by including examples of relatively slow warming, relatively fast warming, and the ensemble mean projection.

To calculate the impact of climate change, tri-monthly divergences were calculated from a reference period of 2005 to 2025 mean for each time series. Then a 20-year running mean of the resulting annual anomalies was calculated for each time series. The 25th, 50th, and 75th quantiles of the differences were selected across all time series. These quantiles represent the spread across climate models of low, medium, and high rates of change in climate conditions under the assumptions of RCP4.5 and RCP8.5.

C.3 Model Results

SNAKE RIVER FALL CHINOOK ESU

Snake River Fall Chinook					
	Percentiles				
Population, scenario	**5%**	**25%**	**50%**	**75%**	**95%**
Abundance Estimates					
Proposed Action	78	2592	8222	26714	266393
QET30 Estimates					
Proposed Action	0.00	0.00	0.00	0.00	0.18
QET50 Estimates					
Proposed Action	0.00	0.00	0.00	0.00	0.38

UPPER COLUMBIA SPRING CHINOOK ESU

Upper Columbia Spring Chinook					
	Percentiles				
Population, scenario	**5%**	**25%**	**50%**	**75%**	**95%**
Abundance Estimates					
Wenatchee River					
Proposed Action	182	339	532	885	1588
Proposed Action+17%	232	458	739	1144	2173
QET30 Estimates					
Wenatchee River					
Proposed Action	0.00	0.00	0.00	0.00	0.00
Proposed Action+17%	0.00	0.00	0.00	0.00	0.00
QET50 Estimates					
Wenatchee River					
Proposed Action	0.00	0.00	0.00	0.00	0.01
Proposed Action+17%	0.00	0.00	0.00	0.00	0.01

SNAKE RIVER SPRING SUMMER CHINOOK

Middle Fork Salmon River MPG Abundance Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
Bear Valley					
Proposed Action	121	242	412	663	1284
Proposed Action+17%	150	306	518	818	1519
Proposed Action+ 35%	190	375	622	993	1770
RCP8.5 low	61	149	243	391	829
RCP8.5 low +17%	79	188	303	480	1005
RCP8.5 low + 35%	99	226	371	575	1151
RCP8.5 mean	53	116	193	340	698
RCP8.5 mean +17%	69	145	238	423	852
RCP8.5 mean + 35%	85	176	292	510	986
RCP8.5 high	38	95	156	265	525
RCP8.5 high +17%	49	120	192	329	661
RCP8.5 high + 35%	62	142	229	397	800
RCP4.5 low	70	151	258	427	794
RCP4.5 low + 17.5%	90	189	320	532	965
RCP4.5 low + 35%	109	228	389	652	1156
RCP4.5 mean	63	134	225	384	714
RCP4.5 mean + 17.5%	78	171	276	478	876
RCP4.5 mean + 35%	91	206	336	577	1080
RCP4.5 high	52	111	191	330	670
RCP4.5 high + 17.5%	64	144	237	409	794
RCP4.5 high + 35%	77	171	290	502	945
Big Creek					
Proposed Action	82	135	194	282	469
Proposed Action+17%	96	158	228	330	551
Proposed Action+ 35%	112	181	262	380	647
RCP8.5 low	52	88	123	177	303
RCP8.5 low +17%	61	102	144	205	356
RCP8.5 low + 35%	69	118	164	234	407
RCP8.5 mean	41	76	109	160	259
RCP8.5 mean +17%	47	88	127	186	297
RCP8.5 mean + 35%	52	100	146	211	342
RCP8.5 high	36	60	89	129	221

Middle Fork Salmon River MPG Abundance Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP8.5 high +17%	42	69	104	148	257
RCP8.5 high + 35%	48	78	118	171	296
RCP4.5 low	55	93	134	191	307
RCP4.5 low + 17.5%	64	109	157	221	355
RCP4.5 low + 35%	72	124	178	252	414
RCP4.5 mean	44	84	120	175	283
RCP4.5 mean + 17.5%	52	98	139	206	338
RCP4.5 mean + 35%	58	112	160	236	391
RCP4.5 high	40	74	109	153	249
RCP4.5 high + 17.5%	46	85	128	181	291
RCP4.5 high + 35%	53	98	146	207	333
Camas Creek					
Proposed Action	19	37	54	82	139
Proposed Action+17%	22	44	64	98	165
Proposed Action+ 35%	26	51	75	114	193
RCP8.5 low	14	24	35	51	90
RCP8.5 low +17%	16	28	41	60	107
RCP8.5 low + 35%	18	33	47	70	123
RCP8.5 mean	11	20	30	44	81
RCP8.5 mean +17%	12	23	35	51	95
RCP8.5 mean + 35%	14	27	41	60	111
RCP8.5 high	8	16	25	37	62
RCP8.5 high +17%	10	19	29	44	74
RCP8.5 high + 35%	11	22	34	50	85
RCP4.5 low	14	25	37	55	96
RCP4.5 low + 17.5%	17	29	43	64	112
RCP4.5 low + 35%	19	33	49	74	130
RCP4.5 mean	12	22	33	49	88
RCP4.5 mean + 17.5%	14	26	39	58	105
RCP4.5 mean + 35%	17	30	45	68	122
RCP4.5 high	10	19	29	45	77
RCP4.5 high + 17.5%	12	23	34	54	92
RCP4.5 high + 35%	14	26	40	62	108
Loon Creek					
Proposed Action	29	52	74	106	191
Proposed Action+17%	34	60	86	123	224

Middle Fork Salmon River MPG Abundance Estimates					
	Percentiles				
Population, scenario	**5%**	**25%**	**50%**	**75%**	**95%**
Proposed Action+ 35%	39	69	100	142	260
RCP8.5 low	20	35	49	68	114
RCP8.5 low +17%	23	41	57	80	135
RCP8.5 low + 35%	26	47	66	92	154
RCP8.5 mean	17	29	41	60	100
RCP8.5 mean +17%	19	33	48	70	121
RCP8.5 mean + 35%	22	38	55	80	138
RCP8.5 high	13	23	34	49	81
RCP8.5 high +17%	15	26	39	57	94
RCP8.5 high + 35%	17	30	45	66	108
RCP4.5 low	20	36	51	74	127
RCP4.5 low + 17.5%	23	42	60	86	148
RCP4.5 low + 35%	26	48	69	100	172
RCP4.5 mean	17	31	46	66	110
RCP4.5 mean + 17.5%	21	37	54	77	127
RCP4.5 mean + 35%	23	42	62	89	151
RCP4.5 high	16	27	40	60	101
RCP4.5 high + 17.5%	18	31	47	69	119
RCP4.5 high + 35%	21	36	53	79	139
Marsh Creek					
Proposed Action	83	154	269	445	850
Proposed Action+17%	101	191	330	542	1046
Proposed Action+ 35%	121	225	395	642	1247
RCP8.5 low	52	101	157	244	544
RCP8.5 low +17%	62	123	191	298	664
RCP8.5 low + 35%	75	145	228	362	783
RCP8.5 mean	41	90	138	226	435
RCP8.5 mean +17%	50	109	170	280	535
RCP8.5 mean + 35%	57	131	204	330	654
RCP8.5 high	32	71	115	181	357
RCP8.5 high +17%	41	85	140	223	436
RCP8.5 high + 35%	48	102	166	265	527
RCP4.5 low	50	103	165	262	519
RCP4.5 low + 17.5%	62	126	203	325	640
RCP4.5 low + 35%	72	154	242	391	756
RCP4.5 mean	45	95	151	262	483

Middle Fork Salmon River MPG Abundance Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP4.5 mean + 17.5%	55	115	186	317	594
RCP4.5 mean + 35%	66	138	223	375	720
RCP4.5 high	41	84	145	236	461
RCP4.5 high + 17.5%	51	103	176	291	562
RCP4.5 high + 35%	60	124	209	345	682
Sulphur Creek					
Proposed Action	23	47	72	118	235
Proposed Action+17%	28	59	90	145	299
Proposed Action+ 35%	33	70	108	175	363
RCP8.5 low	15	28	44	67	138
RCP8.5 low +17%	19	35	55	81	167
RCP8.5 low + 35%	22	41	65	98	205
RCP8.5 mean	11	23	37	63	126
RCP8.5 mean +17%	14	28	46	76	152
RCP8.5 mean + 35%	16	33	54	92	189
RCP8.5 high	9	19	31	49	101
RCP8.5 high +17%	11	23	38	61	124
RCP8.5 high + 35%	14	27	46	72	150
RCP4.5 low	15	29	45	72	143
RCP4.5 low + 17.5%	18	36	56	89	172
RCP4.5 low + 35%	22	43	69	106	213
RCP4.5 mean	13	26	42	70	140
RCP4.5 mean + 17.5%	16	32	52	86	168
RCP4.5 mean + 35%	19	38	62	102	211
RCP4.5 high	11	23	38	61	132
RCP4.5 high + 17.5%	13	28	47	76	165
RCP4.5 high + 35%	15	34	56	91	201

Middle Fork Salmon River MPG QET 30 Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
Bear Valley					
Proposed Action	0.00	0.00	0.01	0.01	0.02
Proposed Action+17%	0.00	0.00	0.00	0.01	0.01
Proposed Action+ 35%	0.00	0.00	0.00	0.00	0.01
RCP8.5 low	0.01	0.02	0.03	0.04	0.07
RCP8.5 low +17%	0.00	0.01	0.02	0.03	0.05
RCP8.5 low + 35%	0.00	0.00	0.01	0.02	0.03
RCP8.5 mean	0.02	0.04	0.05	0.07	0.09
RCP8.5 mean +17%	0.01	0.02	0.03	0.05	0.06
RCP8.5 mean + 35%	0.00	0.01	0.02	0.03	0.05
RCP8.5 high	0.05	0.07	0.09	0.11	0.14
RCP8.5 high +17%	0.02	0.04	0.06	0.07	0.10
RCP8.5 high + 35%	0.01	0.02	0.03	0.04	0.07
RCP4.5 low	0.00	0.02	0.03	0.04	0.06
RCP4.5 low + 17.5%	0.00	0.01	0.02	0.02	0.04
RCP4.5 low + 35%	0.00	0.00	0.01	0.01	0.03
RCP4.5 mean	0.01	0.03	0.05	0.06	0.08
RCP4.5 mean + 17.5%	0.00	0.01	0.02	0.04	0.06
RCP4.5 mean + 35%	0.00	0.01	0.02	0.02	0.04
RCP4.5 high	0.03	0.05	0.06	0.08	0.10
RCP4.5 high + 17.5%	0.01	0.02	0.03	0.04	0.06
RCP4.5 high + 35%	0.00	0.01	0.02	0.02	0.04
Big Creek					
Proposed Action	0.00	0.01	0.02	0.03	0.05
Proposed Action+17%	0.00	0.00	0.01	0.01	0.03
Proposed Action+ 35%	0.00	0.00	0.00	0.01	0.02
RCP8.5 low	0.02	0.04	0.05	0.07	0.10
RCP8.5 low +17%	0.00	0.02	0.03	0.04	0.06
RCP8.5 low + 35%	0.00	0.01	0.02	0.03	0.04
RCP8.5 mean	0.05	0.07	0.09	0.11	0.14
RCP8.5 mean +17%	0.03	0.05	0.07	0.08	0.11
RCP8.5 mean + 35%	0.02	0.03	0.05	0.06	0.09
RCP8.5 high	0.09	0.13	0.15	0.17	0.21
RCP8.5 high +17%	0.06	0.08	0.11	0.13	0.16
RCP8.5 high + 35%	0.03	0.06	0.07	0.09	0.12
RCP4.5 low + 17.5%	0.01	0.02	0.03	0.05	0.06
RCP4.5 low + 35%	0.00	0.01	0.02	0.03	0.05

Middle Fork Salmon River MPG QET 30 Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP4.5 mean	0.04	0.06	0.08	0.09	0.12
RCP4.5 mean + 17.5%	0.02	0.04	0.06	0.07	0.10
RCP4.5 mean + 35%	0.01	0.02	0.03	0.04	0.06
RCP4.5 high	0.06	0.09	0.11	0.13	0.17
RCP4.5 high + 17.5%	0.03	0.05	0.07	0.09	0.12
RCP4.5 high + 35%	0.02	0.04	0.05	0.06	0.09
Camas Creek					
Proposed Action	0.49	0.54	0.57	0.60	0.65
Proposed Action+17%	0.38	0.42	0.46	0.49	0.54
Proposed Action+ 35%	0.28	0.33	0.37	0.40	0.45
RCP8.5 low	0.65	0.69	0.72	0.75	0.79
RCP8.5 low +17%	0.55	0.60	0.64	0.67	0.71
RCP8.5 low + 35%	0.47	0.51	0.54	0.58	0.62
RCP8.5 mean	0.71	0.76	0.79	0.81	0.85
RCP8.5 mean +17%	0.64	0.68	0.72	0.75	0.79
RCP8.5 mean + 35%	0.55	0.60	0.63	0.66	0.71
RCP8.5 high	0.82	0.85	0.88	0.90	0.93
RCP8.5 high +17%	0.75	0.79	0.82	0.85	0.88
RCP8.5 high + 35%	0.66	0.71	0.74	0.77	0.81
RCP4.5 low	0.68	0.72	0.75	0.78	0.82
RCP4.5 low + 17.5%	0.56	0.60	0.63	0.67	0.72
RCP4.5 low + 35%	0.47	0.51	0.54	0.58	0.63
RCP4.5 mean	0.71	0.75	0.77	0.80	0.83
RCP4.5 mean + 17.5%	0.63	0.67	0.71	0.73	0.78
RCP4.5 mean + 35%	0.53	0.58	0.61	0.64	0.69
RCP4.5 high	0.73	0.77	0.80	0.83	0.87
RCP4.5 high + 17.5%	0.66	0.71	0.73	0.76	0.81
RCP4.5 high + 35%	0.57	0.61	0.65	0.68	0.72
Loon Creek					
Proposed Action	0.25	0.30	0.33	0.36	0.40
Proposed Action+17%	0.17	0.21	0.24	0.27	0.32
Proposed Action+ 35%	0.12	0.15	0.18	0.20	0.24
RCP8.5 low	0.41	0.46	0.49	0.53	0.57
RCP8.5 low +17%	0.31	0.36	0.40	0.43	0.48
RCP8.5 low + 35%	0.22	0.27	0.30	0.33	0.37
RCP8.5 mean	0.51	0.56	0.59	0.62	0.67
RCP8.5 mean +17%	0.41	0.46	0.50	0.53	0.57

Middle Fork Salmon River MPG QET 30 Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP8.5 mean + 35%	0.33	0.37	0.41	0.44	0.49
RCP8.5 high	0.67	0.71	0.74	0.77	0.81
RCP8.5 high +17%	0.56	0.61	0.64	0.67	0.72
RCP8.5 high + 35%	0.46	0.50	0.53	0.57	0.62
RCP4.5 low	0.43	0.47	0.50	0.54	0.58
RCP4.5 low + 17.5%	0.31	0.36	0.40	0.43	0.47
RCP4.5 low + 35%	0.23	0.27	0.30	0.33	0.38
RCP4.5 mean	0.50	0.54	0.57	0.61	0.66
RCP4.5 mean + 17.5%	0.39	0.44	0.47	0.51	0.55
RCP4.5 mean + 35%	0.31	0.35	0.38	0.41	0.46
RCP4.5 high	0.54	0.59	0.62	0.66	0.71
RCP4.5 high + 17.5%	0.43	0.48	0.52	0.55	0.60
RCP4.5 high + 35%	0.34	0.39	0.42	0.45	0.50
Marsh Creek					
Proposed Action	0.00	0.02	0.03	0.04	0.06
Proposed Action+17%	0.00	0.01	0.01	0.02	0.04
Proposed Action+ 35%	0.00	0.00	0.01	0.02	0.03
RCP8.5 low	0.02	0.04	0.06	0.07	0.10
RCP8.5 low +17%	0.01	0.03	0.04	0.05	0.07
RCP8.5 low + 35%	0.00	0.01	0.02	0.04	0.05
RCP8.5 mean	0.05	0.08	0.10	0.12	0.15
RCP8.5 mean +17%	0.03	0.05	0.06	0.08	0.11
RCP8.5 mean + 35%	0.02	0.03	0.04	0.06	0.08
RCP8.5 high	0.08	0.12	0.14	0.16	0.20
RCP8.5 high +17%	0.05	0.08	0.10	0.12	0.14
RCP8.5 high + 35%	0.03	0.05	0.07	0.09	0.11
RCP4.5 low	0.03	0.05	0.07	0.09	0.12
RCP4.5 low + 17.5%	0.01	0.03	0.04	0.06	0.08
RCP4.5 low + 35%	0.00	0.01	0.02	0.03	0.05
RCP4.5 mean	0.04	0.06	0.07	0.09	0.12
RCP4.5 mean + 17.5%	0.02	0.04	0.05	0.07	0.09
RCP4.5 mean + 35%	0.01	0.02	0.03	0.05	0.07
RCP4.5 high	0.06	0.09	0.11	0.13	0.16
RCP4.5 high + 17.5%	0.03	0.05	0.07	0.09	0.11
RCP4.5 high + 35%	0.01	0.03	0.04	0.06	0.08
Sulphur Creek					
Proposed Action	0.34	0.39	0.42	0.45	0.50

Middle Fork Salmon River MPG QET 30 Estimates					
	Percentiles				
Population, scenario	**5%**	**25%**	**50%**	**75%**	**95%**
Proposed Action+17%	0.24	0.29	0.32	0.35	0.39
Proposed Action+ 35%	0.18	0.22	0.25	0.28	0.32
RCP8.5 low	0.55	0.60	0.63	0.66	0.70
RCP8.5 low +17%	0.42	0.47	0.50	0.54	0.58
RCP8.5 low + 35%	0.33	0.38	0.41	0.44	0.48
RCP8.5 mean	0.63	0.68	0.71	0.74	0.78
RCP8.5 mean +17%	0.53	0.58	0.62	0.65	0.70
RCP8.5 mean + 35%	0.43	0.47	0.51	0.54	0.59
RCP8.5 high	0.71	0.75	0.78	0.81	0.85
RCP8.5 high +17%	0.61	0.66	0.69	0.72	0.76
RCP8.5 high + 35%	0.51	0.56	0.59	0.62	0.67
RCP4.5 low	0.54	0.59	0.62	0.66	0.71
RCP4.5 low + 17.5%	0.44	0.48	0.52	0.55	0.60
RCP4.5 low + 35%	0.33	0.37	0.41	0.44	0.49
RCP4.5 mean	0.58	0.63	0.66	0.69	0.74
RCP4.5 mean + 17.5%	0.46	0.51	0.54	0.57	0.62
RCP4.5 mean + 35%	0.38	0.42	0.45	0.49	0.54
RCP4.5 high	0.62	0.66	0.69	0.72	0.76
RCP4.5 high + 17.5%	0.50	0.55	0.58	0.61	0.66
RCP4.5 high + 35%	0.41	0.45	0.49	0.52	0.57

Middle Fork Salmon River MPG					
QET 50 Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
Bear Valley					
Proposed Action	0.01	0.03	0.04	0.05	0.08
Proposed Action+17%	0	0.01	0.02	0.02	0.04
Proposed Action+ 35%	0	0	0.01	0.02	0.03
RCP8.5 low	0.05	0.08	0.09	0.11	0.14
RCP8.5 low +17%	0.02	0.04	0.06	0.07	0.1
RCP8.5 low + 35%	0.01	0.02	0.04	0.05	0.07
RCP8.5 mean	0.1	0.13	0.15	0.18	0.21
RCP8.5 mean +17%	0.05	0.07	0.09	0.11	0.14
RCP8.5 mean + 35%	0.03	0.05	0.06	0.08	0.11
RCP8.5 high	0.17	0.21	0.23	0.26	0.3
RCP8.5 high +17%	0.1	0.14	0.16	0.19	0.22
RCP8.5 high + 35%	0.06	0.09	0.11	0.13	0.16
RCP4.5 low	0.05	0.08	0.1	0.12	0.15
RCP4.5 low + 17.5%	0.03	0.05	0.07	0.09	0.11
RCP4.5 low + 35%	0.01	0.02	0.04	0.05	0.07
RCP4.5 mean	0.07	0.1	0.12	0.14	0.18
RCP4.5 mean + 17.5%	0.04	0.06	0.08	0.1	0.13
RCP4.5 mean + 35%	0.02	0.04	0.05	0.06	0.09
RCP4.5 high	0.11	0.14	0.17	0.19	0.23
RCP4.5 high + 17.5%	0.07	0.09	0.11	0.13	0.16
RCP4.5 high + 35%	0.03	0.06	0.07	0.09	0.12
Big Creek					
Proposed Action	0.06	0.09	0.11	0.13	0.16
Proposed Action+17%	0.03	0.05	0.06	0.08	0.11
Proposed Action+ 35%	0.01	0.03	0.04	0.06	0.08
RCP8.5 low	0.16	0.2	0.23	0.26	0.31
RCP8.5 low +17%	0.1	0.13	0.16	0.18	0.22
RCP8.5 low + 35%	0.06	0.09	0.11	0.13	0.16
RCP8.5 mean	0.23	0.278	0.3	0.33	0.38
RCP8.5 mean +17%	0.16	0.2	0.23	0.26	0.3
RCP8.5 mean + 35%	0.11	0.14	0.17	0.19	0.23
RCP8.5 high	0.36	0.41	0.45	0.48	0.53
RCP8.5 high +17%	0.27	0.32	0.35	0.38	0.43
RCP8.5 high + 35%	0.19	0.23	0.26	0.29	0.33
RCP4.5 low	0.17	0.21	0.24	0.27	0.3
RCP4.5 low + 17.5%	0.1	0.13	0.15	0.18	0.22

Middle Fork Salmon River MPG					
QET 50 Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP4.5 low + 35%	0.06	0.09	0.11	0.13	0.17
RCP4.5 mean	0.2	0.24	0.27	0.3	0.34
RCP4.5 mean + 17.5%	0.14	0.17	0.2	0.22	0.27
RCP4.5 mean + 35%	0.09	0.12	0.14	0.17	0.2
RCP4.5 high	0.24	0.29	0.32	0.35	0.4
RCP4.5 high + 17.5%	0.17	0.22	0.24	0.27	0.32
RCP4.5 high + 35%	0.13	0.16	0.18	0.21	0.25
Camas Creek					
Proposed Action	0.8	0.83	0.86	0.88	0.91
Proposed Action+17%	0.72	0.76	0.78	0.81	0.85
Proposed Action+ 35%	0.62	0.67	0.71	0.73	0.78
RCP8.5 low	0.9	0.93	0.95	0.96	0.98
RCP8.5 low +17%	0.85	0.88	0.9	0.92	0.95
RCP8.5 low + 35%	0.78	0.82	0.84	0.87	0.9
RCP8.5 mean	0.92	0.94	0.96	0.97	0.99
RCP8.5 mean +17%	0.88	0.91	0.93	0.95	0.97
RCP8.5 mean + 35%	0.84	0.87	0.89	0.92	0.94
RCP8.5 high	0.96	0.97	0.98	0.99	1
RCP8.5 high +17%	0.94	0.96	0.97	0.98	0.99
RCP8.5 high + 35%	0.9	0.93	0.95	0.96	0.98
RCP4.5 low	0.9	0.92	0.94	0.96	0.98
RCP4.5 low + 17.5%	0.84	0.87	0.89	0.91	0.94
RCP4.5 low + 35%	0.78	0.82	0.85	0.87	0.91
RCP4.5 mean	0.91	0.93	0.95	0.96	0.98
RCP4.5 mean + 17.5%	0.87	0.89	0.91	0.93	0.96
RCP4.5 mean + 35%	0.819	0.85	0.87	0.9	0.93
RCP4.5 high	0.93	0.95	0.96	0.98	0.99
RCP4.5 high + 17.5%	0.88	0.91	0.92	0.94	0.97
RCP4.5 high + 35%	0.83	0.86	0.88	0.91	0.93
Loon Creek					
Proposed Action	0.63	0.67	0.7	0.73	0.77
Proposed Action+17%	0.53	0.58	0.61	0.64	0.69
Proposed Action+ 35%	0.42	0.47	0.5	0.53	0.59
RCP8.5 low	0.79	0.83	0.85	0.87	0.91
RCP8.5 low +17%	0.7	0.75	0.78	0.8	0.84
RCP8.5 low + 35%	0.61	0.65	0.68	0.71	0.75
RCP8.5 mean	0.83	0.86	0.89	0.91	0.93

Middle Fork Salmon River MPG					
QET 50 Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP8.5 mean +17%	0.77	0.8	0.83	0.85	0.88
RCP8.5 mean + 35%	0.69	0.73	0.76	0.79	0.83
RCP8.5 high	0.89	0.92	0.94	0.95	0.97
RCP8.5 high +17%	0.85	0.88	0.9	0.92	0.95
RCP8.5 high + 35%	0.8	0.84	0.86	0.88	0.91
RCP4.5 low	0.78	0.81	0.84	0.86	0.9
RCP4.5 low + 17.5%	0.69	0.73	0.76	0.79	0.83
RCP4.5 low + 35%	0.59	0.64	0.67	0.7	0.75
RCP4.5 mean	0.82	0.86	0.88	0.9	0.93
RCP4.5 mean + 17.5%	0.75	0.79	0.82	0.84	0.88
RCP4.5 mean + 35%	0.67	0.72	0.75	0.77	0.82
RCP4.5 high	0.84	0.87	0.89	0.91	0.94
RCP4.5 high + 17.5%	0.79	0.82	0.85	0.87	0.9
RCP4.5 high + 35%	0.71	0.75	0.78	0.81	0.84
Marsh Creek					
Proposed Action	0.05	0.09	0.11	0.13	0.16
Proposed Action+17%	0.03	0.05	0.06	0.08	0.11
Proposed Action+ 35%	0.01	0.03	0.04	0.05	0.08
RCP8.5 low	0.15	0.19	0.21	0.24	0.28
RCP8.5 low +17%	0.09	0.12	0.14	0.17	0.2
RCP8.5 low + 35%	0.05	0.08	0.09	0.11	0.15
RCP8.5 mean	0.2	0.24	0.26	0.29	0.34
RCP8.5 mean +17%	0.14	0.17	0.2	0.23	0.27
RCP8.5 mean + 35%	0.09	0.12	0.15	0.17	0.2
RCP8.5 high	0.28	0.32	0.36	0.39	0.44
RCP8.5 high +17%	0.18	0.22	0.25	0.28	0.32
RCP8.5 high + 35%	0.12	0.16	0.18	0.21	0.24
RCP4.5 low	0.16	0.19	0.22	0.25	0.29
RCP4.5 low + 17.5%	0.1	0.13	0.15	0.17	0.21
RCP4.5 low + 35%	0.06	0.08	0.1	0.12	0.16
RCP4.5 mean	0.19	0.23	0.26	0.29	0.33
RCP4.5 mean + 17.5%	0.12	0.15	0.18	0.21	0.24
RCP4.5 mean + 35%	0.07	0.1	0.12	0.14	0.18
RCP4.5 high	0.2	0.24	0.27	0.3	0.35
RCP4.5 high + 17.5%	0.14	0.17	0.2	0.23	0.27
RCP4.5 high + 35%	0.08	0.11	0.13	0.16	0.19
Sulphur Creek					

Middle Fork Salmon River MPG					
QET 50 Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
Proposed Action	0.66	0.71	0.74	0.77	0.81
Proposed Action+17%	0.55	0.6	0.63	0.66	0.7
Proposed Action+ 35%	0.43	0.48	0.51	0.54	0.59
RCP8.5 low	0.83	0.86	0.88	0.9	0.93
RCP8.5 low +17%	0.74	0.78	0.8	0.83	0.87
RCP8.5 low + 35%	0.63	0.68	0.71	0.74	0.79
RCP8.5 mean	0.83	0.86	0.89	0.91	0.94
RCP8.5 mean +17%	0.76	0.8	0.83	0.85	0.88
RCP8.5 mean + 35%	0.69	0.73	0.76	0.79	0.82
RCP8.5 high	0.9	0.92	0.94	0.96	0.98
RCP8.5 high +17%	0.85	0.88	0.9	0.92	0.94
RCP8.5 high + 35%	0.78	0.82	0.84	0.86	0.89
RCP4.5 low	0.82	0.85	0.88	0.9	0.93
RCP4.5 low + 17.5%	0.73	0.77	0.8	0.83	0.87
RCP4.5 low + 35%	0.62	0.67	0.7	0.73	0.78
RCP4.5 mean	0.82	0.86	0.88	0.91	0.93
RCP4.5 mean + 17.5%	0.74	0.78	0.81	0.83	0.87
RCP4.5 mean + 35%	0.65	0.7	0.73	0.76	0.81
RCP4.5 high	0.84	0.87	0.89	0.91	0.94
RCP4.5 high + 17.5%	0.77	0.81	0.84	0.86	0.9
RCP4.5 high + 35%	0.689	0.73	0.76	0.78	0.82

South Fork Salmon River MPG					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
Abundance Estimates					
Secesh River					
Proposed Action	154	364	556	916	1843
Proposed Action+17%	198	446	688	1139	2180
Proposed Action+ 35%	256	539	840	1357	2528
RCP8.5 low	89	194	323	529	1049
RCP8.5 low +17%	112	243	406	663	1281
RCP8.5 low + 35%	136	292	484	796	1495
RCP8.5 mean	74	173	286	471	1001
RCP8.5 mean +17%	92	213	353	583	1203
RCP8.5 mean + 35%	114	258	426	707	1412
RCP8.5 high	57	136	235	391	763
RCP8.5 high +17%	70	168	295	488	939
RCP8.5 high + 35%	85	205	352	594	1112
RCP4.5 low	87	201	349	566	1161
RCP4.5 low + 17.5%	110	251	429	706	1414
RCP4.5 low + 35%	132	301	521	851	1639
RCP4.5 mean	87	186	316	515	1028
RCP4.5 mean + 17.5%	104	232	389	644	1270
RCP4.5 mean + 35%	126	277	469	778	1470
RCP4.5 high	68	167	287	493	986
RCP4.5 high + 17.5%	86	207	361	609	1216
RCP4.5 high + 35%	108	252	436	733	1456
QET30 Estimates					
Secesh River					
Proposed Action	0.00	0.00	0.01	0.01	0.02
Proposed Action+17.5%	0.00	0.00	0.00	0.01	0.02
Proposed Action+ 35%	0.00	0.00	0.00	0.01	0.02
RCP8.5 low	0.00	0.01	0.02	0.03	0.05
RCP8.5 low +17%	0.00	0.00	0.01	0.02	0.03
RCP8.5 low + 35%	0.00	0.00	0.00	0.01	0.02
RCP8.5 mean	0.01	0.02	0.03	0.05	0.07
RCP8.5 mean +17%	0.00	0.01	0.02	0.03	0.05
RCP8.5 mean + 35%	0.00	0.01	0.01	0.02	0.04
RCP8.5 high	0.02	0.03	0.05	0.06	0.09
RCP8.5 high +17%	0.01	0.02	0.03	0.04	0.06
RCP8.5 high + 35%	0.00	0.01	0.02	0.04	0.05
RCP4.5 low	0.00	0.01	0.02	0.04	0.06

South Fork Salmon River MPG					
	Percentiles				
Population, scenario	**5%**	**25%**	**50%**	**75%**	**95%**
RCP4.5 low + 17.5%	0.00	0.00	0.01	0.02	0.03
RCP4.5 low + 35%	0.00	0.00	0.00	0.01	0.02
RCP4.5 mean	0.00	0.01	0.02	0.03	0.05
RCP4.5 mean + 17.5%	0.00	0.00	0.01	0.02	0.03
RCP4.5 mean + 35%	0.00	0.00	0.01	0.01	0.02
RCP4.5 high	0.00	0.02	0.03	0.04	0.06
RCP4.5 high + 17.5%	0.00	0.00	0.01	0.02	0.03
RCP4.5 high + 35%	0.00	0.00	0.00	0.01	0.02
QET50					
Secesh River					
Proposed Action	0.00	0.02	0.03	0.04	0.06
Proposed Action+17.5%	0.00	0.00	0.01	0.02	0.03
Proposed Action+ 35%	0.00	0.00	0.00	0.01	0.02
RCP8.5 low	0.03	0.05	0.06	0.08	0.10
RCP8.5 low +17%	0.01	0.02	0.03	0.05	0.07
RCP8.5 low + 35%	0.00	0.01	0.02	0.03	0.05
RCP8.5 mean	0.04	0.07	0.08	0.10	0.13
RCP8.5 mean +17%	0.02	0.04	0.06	0.07	0.10
RCP8.5 mean + 35%	0.01	0.03	0.04	0.05	0.07
RCP8.5 high	0.08	0.11	0.12	0.15	0.18
RCP8.5 high +17%	0.05	0.07	0.09	0.11	0.14
RCP8.5 high + 35%	0.03	0.04	0.06	0.07	0.10
RCP4.5 low	0.02	0.04	0.06	0.08	0.10
RCP4.5 low + 17.5%	0.01	0.03	0.04	0.05	0.08
RCP4.5 low + 35%	0.00	0.02	0.03	0.04	0.06
RCP4.5 mean	0.04	0.06	0.08	0.10	0.12
RCP4.5 mean + 17.5%	0.01	0.02	0.04	0.05	0.08
RCP4.5 mean + 35%	0.00	0.01	0.02	0.03	0.05
RCP4.5 high	0.05	0.08	0.10	0.12	0.15
RCP4.5 high + 17.5%	0.03	0.04	0.06	0.08	0.10
RCP4.5 high + 35%	0.01	0.02	0.03	0.05	0.06

Grand Ronde MPG Abundance Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
Natural and Hatchery Origin Spawners					
Catherine Creek					
Proposed Action	280	491	679	950	1429
Proposed Action+17%	366	584	810	1115	1746
Proposed Action+ 35%	429	692	965	1307	1991
RCP8.5 low	205	354	489	655	999
RCP8.5 low +17%	269	419	582	773	1273
RCP8.5 low + 35%	315	496	680	889	1448
RCP8.5 mean	170	274	388	542	890
RCP8.5 mean +17%	202	335	459	653	1038
RCP8.5 mean + 35%	239	396	543	753	1192
RCP8.5 high	130	216	306	428	649
RCP8.5 high +17%	158	270	366	509	775
RCP8.5 high + 35%	189	312	428	593	935
RCP 4.5 low	220	357	517	703	1073
RCP 4.5 low + 17%	272	445	616	848	1292
RCP 4.5 low + 35%	345	531	712	986	1457
RCP 4.5 med	186	308	435	610	1016
RCP 4.5 med + 17%	232	369	511	730	1175
RCP 4.5 med + 35%	292	443	614	835	1350
RCP 4.5 high	155	242	360	503	823
RCP 4.5 high + 17%	181	299	433	597	956
RCP 4.5 high + 35%	221	354	516	697	1118
Lostine					
Proposed Action	355	519	658	846	1181
Proposed Action+17%	415	605	751	965	1328
Proposed Action+ 35%	475	681	858	1083	1483
RCP8.5 low	254	375	480	610	883
RCP8.5 low +17%	309	439	552	704	1017
RCP8.5 low + 35%	355	505	629	795	1148
RCP8.5 mean	187	289	377	529	740
RCP8.5 mean +17%	224	335	440	602	861
RCP8.5 mean + 35%	261	384	505	684	962
RCP8.5 high	139	222	302	404	595
RCP8.5 high +17%	161	261	353	473	681

Grand Ronde MPG Abundance Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP8.5 high + 35%	193	304	408	534	783
RCP 4.5 low	240	384	502	649	912
RCP 4.5 low + 17%	288	456	587	743	1037
RCP 4.5 low + 35%	335	518	664	830	1150
RCP 4.5 med	216	324	438	579	840
RCP 4.5 med + 17%	253	384	501	662	949
RCP 4.5 med + 35%	297	440	578	748	1068
RCP 4.5 high	171	265	365	474	706
RCP 4.5 high + 17%	196	310	424	547	802
RCP 4.5 high + 35%	230	359	488	619	910
Upper Grande Ronde					
Proposed Action	265	426	567	768	1164
Proposed Action+17%	317	510	668	895	1333
Proposed Action+ 35%	379	595	767	1035	1545
RCP8.5 low	185	292	387	513	817
RCP8.5 low +17%	229	351	462	612	927
RCP8.5 low + 35%	270	409	530	699	1059
RCP8.5 mean	126	212	293	434	654
RCP8.5 mean +17%	162	260	353	510	770
RCP8.5 mean + 35%	194	305	415	592	885
RCP8.5 high	94	158	226	310	496
RCP8.5 high +17%	111	193	271	372	584
RCP8.5 high + 35%	139	230	324	434	684
RCP 4.5 low	179	302	415	561	830
RCP 4.5 low + 17%	217	366	491	654	966
RCP 4.5 low + 35%	258	426	563	753	1094
RCP 4.5 med	157	250	346	477	746
RCP 4.5 med + 17%	192	303	411	567	857
RCP 4.5 med + 35%	224	356	481	653	993
RCP 4.5 high	116	188	275	379	615
RCP 4.5 high + 17%	143	232	334	457	716
RCP 4.5 high + 35%	168	275	391	528	822
Wild origin spawners					
Catherine Creek					
Proposed Action	126	226	313	446	679
Proposed Action+17%	166	268	376	526	835
Proposed Action+ 35%	196	320	451	620	958

Grand Ronde MPG Abundance Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP8.5 low	88	160	222	302	469
RCP8.5 low +17%	120	190	266	358	602
RCP8.5 low + 35%	141	228	315	415	689
RCP8.5 mean	72	122	172	247	416
RCP8.5 mean +17%	89	150	207	300	487
RCP8.5 mean + 35%	105	178	247	348	565
RCP8.5 high	53	93	134	194	298
RCP8.5 high +17%	67	117	162	231	359
RCP8.5 high + 35%	81	137	191	272	437
RCP 4.5 low	95	161	237	326	502
RCP 4.5 low + 17%	121	202	284	393	613
RCP 4.5 low + 35%	155	243	330	462	694
RCP 4.5 med	80	136	197	281	475
RCP 4.5 med + 17%	102	166	233	338	556
RCP 4.5 med + 35%	130	201	282	389	642
RCP 4.5 high	65	106	162	228	383
RCP 4.5 high + 17%	78	132	197	273	449
RCP 4.5 high + 35%	98	159	234	321	526
Lostine River					
Proposed Action	102	173	233	325	513
Proposed Action+17%	129	206	281	394	612
Proposed Action+ 35%	146	246	336	448	701
RCP8.5 low	66	114	159	219	351
RCP8.5 low +17%	89	143	193	269	422
RCP8.5 low + 35%	108	171	232	313	505
RCP8.5 mean	45	84	123	188	292
RCP8.5 mean +17%	60	102	148	221	357
RCP8.5 mean + 35%	74	124	178	259	406
RCP8.5 high	34	62	92	135	224
RCP8.5 high +17%	41	77	114	166	267
RCP8.5 high + 35%	51	95	137	195	323
RCP 4.5 low	68	122	170	232	373
RCP 4.5 low + 17%	89	153	205	279	452
RCP 4.5 low + 35%	107	179	248	325	517
RCP 4.5 med	61	99	143	204	344
RCP 4.5 med + 17%	72	125	177	250	401
RCP 4.5 med + 35%	90	146	208	292	468

Grand Ronde MPG Abundance Estimates					
	Percentiles				
Population, scenario	**5%**	**25%**	**50%**	**75%**	**95%**
RCP 4.5 high	42	75	114	165	280
RCP 4.5 high + 17%	52	95	139	199	330
RCP 4.5 high + 35%	65	114	165	233	387
Minam River					
Proposed Action	1	29	217	853	2999
Proposed Action+17%	2	86	465	1453	3779
Proposed Action+ 35%	7	170	843	2155	4762
RCP8.5 low	1	18	123	535	1752
RCP8.5 low +17%	3	52	268	881	2563
RCP8.5 low + 35%	8	119	450	1275	3293
RCP8.5 mean	1	11	91	374	1410
RCP8.5 mean +17%	2	30	190	610	1904
RCP8.5 mean + 35%	6	68	331	934	2473
RCP8.5 high	1	8	61	237	990
RCP8.5 high +17%	1	25	127	424	1399
RCP8.5 high + 35%	4	58	230	664	1806
RCP 4.5 low	1	20	139	562	1874
RCP 4.5 low + 17%	2	60	311	950	2491
RCP 4.5 low + 35%	5	122	555	1385	3350
RCP 4.5 med	1	14	110	387	1667
RCP 4.5 med + 17%	2	40	238	681	2278
RCP 4.5 med + 35%	6	102	401	1058	3103
RCP 4.5 high	1	11	71	319	1198
RCP 4.5 high + 17%	2	30	158	564	1636
RCP 4.5 high + 35%	4	67	305	870	2221
Upper Grande Ronde					
Proposed Action	34	50	66	87	123
Proposed Action+17%	39	57	74	99	142
Proposed Action+ 35%	46	66	85	114	161
RCP8.5 low	26	37	48	61	93
RCP8.5 low +17%	30	43	55	72	104
RCP8.5 low + 35%	34	49	63	80	120
RCP8.5 mean	20	29	39	52	81
RCP8.5 mean +17%	23	34	46	60	92
RCP8.5 mean + 35%	26	39	51	68	101
RCP8.5 high	16	24	31	42	61
RCP8.5 high +17%	19	28	36	48	70

Grand Ronde MPG Abundance Estimates					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP8.5 high + 35%	21	32	42	56	78
RCP 4.5 low	25	39	51	66	96
RCP 4.5 low + 17%	30	45	59	76	111
RCP 4.5 low + 35%	34	52	65	84	123
RCP 4.5 med	23	34	44	57	84
RCP 4.5 med + 17%	27	39	51	68	99
RCP 4.5 med + 35%	31	44	58	75	113
RCP 4.5 high	18	27	37	50	75
RCP 4.5 high + 17%	21	32	43	56	85
RCP 4.5 high + 35%	24	37	48	64	94
Wenaha River					
Proposed Action	5	58	195	616	2248
Proposed Action+17%	22	140	446	1254	3533
Proposed Action+ 35%	56	301	844	2105	5345
RCP8.5 low	6	38	106	286	1308
RCP8.5 low +17%	22	94	247	627	2077
RCP8.5 low + 35%	49	199	482	1109	3056
RCP8.5 mean	4	24	68	219	973
RCP8.5 mean +17%	12	63	170	459	1701
RCP8.5 mean + 35%	31	131	328	812	2455
RCP8.5 high	2	15	50	152	657
RCP8.5 high +17%	7	41	116	316	1107
RCP8.5 high + 35%	18	86	240	544	1793
RCP 4.5 low	6	39	112	335	1346
RCP 4.5 low + 17%	20	100	271	685	2286
RCP 4.5 low + 35%	50	213	505	1226	3389
RCP 4.5 med	5	30	88	265	1233
RCP 4.5 med + 17%	17	74	201	516	2079
RCP 4.5 med + 35%	46	165	399	945	3066
RCP 4.5 high	3	19	61	189	732
RCP 4.5 high + 17%	10	50	140	419	1407
RCP 4.5 high + 35%	26	107	289	703	1986

Grand Ronde MPG QET 50					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
Natural and Hatchery Origin Spawners					
Catherine Creek					
Proposed Action	0.00	0.00	0.00	0.00	0.01
Proposed Action+17%	0.00	0.00	0.00	0.00	0.00
Proposed Action+ 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 low	0.00	0.00	0.00	0.00	0.01
RCP8.5 low +17%	0.00	0.00	0.00	0.00	0.00
RCP8.5 low + 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 mean	0.00	0.00	0.00	0.01	0.01
RCP8.5 mean +17%	0.00	0.00	0.00	0.00	0.01
RCP8.5 mean + 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 high	0.00	0.00	0.00	0.00	0.01
RCP8.5 high +17%	0.00	0.00	0.00	0.00	0.00
RCP8.5 high + 35%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 low	0.00	0.00	0.00	0.00	0.01
RCP 4.5 low + 17%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 low + 35%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 med	0.00	0.00	0.00	0.00	0.00
RCP 4.5 med + 17%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 med + 35%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 high	0.00	0.00	0.00	0.00	0.00
RCP 4.5 high + 17%	0.00	0.00	0.00	0.00	0.01
RCP 4.5 high + 35%	0.00	0.00	0.00	0.00	0.00
Lostine					
Proposed Action	0.00	0.00	0.00	0.00	0.00
Proposed Action+17%	0.00	0.00	0.00	0.00	0.00
Proposed Action+ 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 low	0.00	0.00	0.00	0.00	0.00
RCP8.5 low +17%	0.00	0.00	0.00	0.00	0.00
RCP8.5 low + 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 mean	0.00	0.00	0.00	0.00	0.00
RCP8.5 mean +17%	0.00	0.00	0.00	0.00	0.00
RCP8.5 mean + 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 high	0.00	0.00	0.00	0.00	0.00
RCP8.5 high +17%	0.00	0.00	0.00	0.00	0.00
RCP8.5 high + 35%	0.00	0.00	0.00	0.00	0.00

Grand Ronde MPG QET 50					
	Percentiles				
Population, scenario	**5%**	**25%**	**50%**	**75%**	**95%**
RCP 4.5 low	0.00	0.00	0.00	0.00	0.00
RCP 4.5 low + 17%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 low + 35%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 med	0.00	0.00	0.00	0.00	0.00
RCP 4.5 med + 17%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 med + 35%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 high	0.00	0.00	0.00	0.00	0.00
RCP 4.5 high + 17%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 high + 35%	0.00	0.00	0.00	0.00	0.00
Upper Grande Ronde					
Proposed Action	0.00	0.00	0.00	0.00	0.00
Proposed Action+17%	0.00	0.00	0.00	0.00	0.00
Proposed Action+ 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 low	0.00	0.00	0.00	0.00	0.00
RCP8.5 low +17%	0.00	0.00	0.00	0.00	0.00
RCP8.5 low + 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 mean	0.00	0.00	0.00	0.00	0.00
RCP8.5 mean +17%	0.00	0.00	0.00	0.00	0.00
RCP8.5 mean + 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 high	0.00	0.00	0.00	0.00	0.00
RCP8.5 high +17%	0.00	0.00	0.00	0.00	0.00
RCP8.5 high + 35%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 low	0.00	0.00	0.00	0.00	0.00
RCP 4.5 low + 17%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 low + 35%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 med	0.00	0.00	0.00	0.00	0.01
RCP 4.5 med + 17%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 med + 35%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 high	0.00	0.00	0.00	0.00	0.00
RCP 4.5 high + 17%	0.00	0.00	0.00	0.00	0.00
RCP 4.5 high + 35%	0.00	0.00	0.00	0.00	0.00
Wild origin spawners					
Catherine Creek					
Proposed Action	0.03	0.05	0.07	0.08	0.10
Proposed Action+17%	0.01	0.02	0.02	0.03	0.05
Proposed Action+ 35%	0.00	0.01	0.01	0.02	0.04

Grand Ronde MPG QET 50					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP8.5 low	0.03	0.05	0.06	0.08	0.09
RCP8.5 low +17%	0.00	0.01	0.02	0.04	0.05
RCP8.5 low + 35%	0.00	0.01	0.01	0.02	0.04
RCP8.5 mean	0.05	0.07	0.09	0.10	0.14
RCP8.5 mean +17%	0.02	0.03	0.05	0.06	0.09
RCP8.5 mean + 35%	0.00	0.02	0.02	0.04	0.05
RCP8.5 high	0.08	0.11	0.13	0.15	0.19
RCP8.5 high +17%	0.03	0.06	0.07	0.09	0.12
RCP8.5 high + 35%	0.01	0.03	0.05	0.06	0.08
RCP 4.5 low	0.02	0.04	0.06	0.07	0.10
RCP 4.5 low + 17%	0.00	0.02	0.03	0.04	0.05
RCP 4.5 low + 35%	0.00	0.01	0.01	0.02	0.03
RCP 4.5 med	0.05	0.07	0.09	0.11	0.13
RCP 4.5 med + 17%	0.02	0.04	0.05	0.06	0.08
RCP 4.5 med + 35%	0.00	0.01	0.01	0.02	0.04
RCP 4.5 high	0.07	0.09	0.11	0.13	0.17
RCP 4.5 high + 17%	0.02	0.04	0.05	0.07	0.10
RCP 4.5 high + 35%	0.00	0.01	0.02	0.03	0.05
Lostine River					
Proposed Action	0.00	0.00	0.00	0.01	0.01
Proposed Action+17%	0.00	0.00	0.00	0.00	0.00
Proposed Action+ 35%	0.00	0.00	0.00	0.00	0.01
RCP8.5 low	0.00	0.01	0.01	0.02	0.03
RCP8.5 low +17%	0.00	0.00	0.00	0.00	0.01
RCP8.5 low + 35%	0.00	0.00	0.00	0.00	0.00
RCP8.5 mean	0.03	0.04	0.06	0.08	0.10
RCP8.5 mean +17%	0.00	0.01	0.02	0.03	0.05
RCP8.5 mean + 35%	0.00	0.00	0.01	0.01	0.02
RCP8.5 high	0.10	0.12	0.14	0.17	0.19
RCP8.5 high +17%	0.04	0.07	0.08	0.09	0.12
RCP8.5 high + 35%	0.01	0.03	0.04	0.05	0.07
RCP 4.5 low	0.00	0.00	0.01	0.02	0.03
RCP 4.5 low + 17%	0.00	0.00	0.00	0.01	0.02
RCP 4.5 low + 35%	0.00	0.00	0.00	0.00	0.01
RCP 4.5 med	0.00	0.01	0.02	0.03	0.05

Grand Ronde MPG QET 50					
	Percentiles				
Population, scenario	**5%**	**25%**	**50%**	**75%**	**95%**
RCP 4.5 med + 17%	0.00	0.00	0.01	0.02	0.03
RCP 4.5 med + 35%	0.00	0.00	0.00	0.01	0.02
RCP 4.5 high	0.05	0.07	0.08	0.10	0.12
RCP 4.5 high + 17%	0.01	0.02	0.04	0.05	0.07
RCP 4.5 high + 35%	0.00	0.01	0.02	0.03	0.05
Minam River					
Proposed Action	0.22	0.25	0.28	0.31	0.35
Proposed Action+17%	0.12	0.14	0.17	0.20	0.23
Proposed Action+ 35%	0.07	0.09	0.12	0.14	0.16
RCP8.5 low	0.27	0.31	0.34	0.38	0.41
RCP8.5 low +17%	0.15	0.18	0.20	0.23	0.26
RCP8.5 low + 35%	0.09	0.11	0.14	0.15	0.18
RCP8.5 mean	0.32	0.36	0.39	0.42	0.45
RCP8.5 mean +17%	0.23	0.26	0.29	0.32	0.37
RCP8.5 mean + 35%	0.13	0.15	0.18	0.20	0.25
RCP8.5 high	0.35	0.40	0.43	0.47	0.52
RCP8.5 high +17%	0.26	0.30	0.33	0.37	0.41
RCP8.5 high + 35%	0.14	0.18	0.21	0.23	0.29
RCP 4.5 low	0.25	0.30	0.33	0.35	0.40
RCP 4.5 low + 17%	0.14	0.18	0.20	0.23	0.28
RCP 4.5 low + 35%	0.08	0.11	0.14	0.16	0.18
RCP 4.5 med	0.29	0.33	0.37	0.41	0.44
RCP 4.5 med + 17%	0.18	0.22	0.25	0.28	0.31
RCP 4.5 med + 35%	0.10	0.14	0.16	0.18	0.23
RCP 4.5 high	0.34	0.38	0.41	0.44	0.48
RCP 4.5 high + 17%	0.23	0.26	0.29	0.32	0.37
RCP 4.5 high + 35%	0.13	0.16	0.18	0.21	0.25
Upper Grande Ronde					
Proposed Action	0.40	0.45	0.48	0.50	0.54
Proposed Action+17%	0.29	0.33	0.37	0.40	0.43
Proposed Action+ 35%	0.21	0.24	0.27	0.29	0.34
RCP8.5 low	0.53	0.58	0.61	0.65	0.69
RCP8.5 low +17%	0.38	0.43	0.45	0.48	0.53
RCP8.5 low + 35%	0.26	0.29	0.32	0.35	0.40
RCP8.5 mean	0.66	0.69	0.72	0.74	0.78

Grand Ronde MPG QET 50					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP8.5 mean +17%	0.53	0.56	0.59	0.62	0.68
RCP8.5 mean + 35%	0.42	0.47	0.50	0.52	0.57
RCP8.5 high	0.77	0.80	0.83	0.85	0.88
RCP8.5 high +17%	0.69	0.72	0.75	0.78	0.82
RCP8.5 high + 35%	0.55	0.59	0.63	0.65	0.69
RCP 4.5 low	0.51	0.55	0.58	0.61	0.64
RCP 4.5 low + 17%	0.36	0.40	0.44	0.46	0.51
RCP 4.5 low + 35%	0.26	0.30	0.33	0.35	0.39
RCP 4.5 med	0.59	0.63	0.66	0.69	0.74
RCP 4.5 med + 17%	0.47	0.51	0.54	0.57	0.63
RCP 4.5 med + 35%	0.34	0.37	0.41	0.44	0.49
RCP 4.5 high	0.69	0.72	0.74	0.76	0.79
RCP 4.5 high + 17%	0.58	0.61	0.65	0.69	0.74
RCP 4.5 high + 35%	0.46	0.49	0.53	0.55	0.59
Wenaha River					
Proposed Action	0.14	0.17	0.20	0.22	0.25
Proposed Action+17%	0.05	0.07	0.09	0.10	0.14
Proposed Action+ 35%	0.01	0.02	0.03	0.04	0.07
RCP8.5 low	0.19	0.24	0.26	0.29	0.33
RCP8.5 low +17%	0.06	0.08	0.11	0.13	0.16
RCP8.5 low + 35%	0.01	0.02	0.03	0.05	0.07
RCP8.5 mean	0.31	0.34	0.37	0.41	0.46
RCP8.5 mean +17%	0.12	0.15	0.18	0.21	0.23
RCP8.5 mean + 35%	0.04	0.06	0.07	0.08	0.11
RCP8.5 high	0.39	0.43	0.46	0.49	0.53
RCP8.5 high +17%	0.21	0.24	0.27	0.30	0.34
RCP8.5 high + 35%	0.08	0.11	0.13	0.15	0.18
RCP 4.5 low	0.20	0.23	0.25	0.28	0.32
RCP 4.5 low + 17%	0.06	0.09	0.11	0.12	0.16
RCP 4.5 low + 35%	0.00	0.02	0.04	0.05	0.06
RCP 4.5 med	0.25	0.30	0.33	0.35	0.40
RCP 4.5 med + 17%	0.09	0.13	0.15	0.17	0.19
RCP 4.5 med + 35%	0.02	0.04	0.05	0.06	0.08
RCP 4.5 high	0.31	0.36	0.39	0.43	0.47
RCP 4.5 high + 17%	0.16	0.19	0.21	0.24	0.27

Grand Ronde MPG QET 50					
	Percentiles				
Population, scenario	5%	25%	50%	75%	95%
RCP 4.5 high + 35%	0.06	0.08	0.09	0.12	0.15

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