



Columbia River System Operations Final Environmental Impact Statement

Appendix V, Endangered Species Act Consultation

Part 1, Columbia River System 2020 Biological Assessment

Note: The Section 508 amendment of the Rehabilitation Act of 1973 requires that the information in federal documents be accessible to individuals with disabilities. The Agency has made every effort to ensure that the information in *Appendix V: Endangered Species Act Consultation for the Columbia River System Operations Environmental Impact Statement* is accessible. However, if readers have any issues accessing the information in this appendix, please contact the U.S. Army Corps of Engineers at (800) 290-5033 or info@crso.info so additional accommodations may be provided.

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ESA Section 7(a)(2) Consultation Package

An Endangered Species Act (ESA) consultation is ongoing with National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) in concert with the Columbia River System Operations (CRSO) National Environmental Policy Act (NEPA) process. The Preferred Alternative from the CRSO draft Environmental Impact Statement (EIS) accordingly forms the basis for the proposed action described in this Biological Assessment (BA). The co-lead agencies do not plan to update the content of this BA, but will continue coordinating with NMFS and USFWS (collectively, the “Services”) to clarify content of this BA as needed. If the clarifications affect the Preferred Alternative, the co-lead agencies will include those changes in the draft or final EIS.

In addition, the co-lead agencies are continuing to engage with tribal sovereigns, cooperating agencies, and other stakeholders and will be receiving comments on the Preferred Alternative during the public comment period following release of the draft EIS. Should there be any changes made during the EIS process to the Preferred Alternative that are relevant to the ESA consultation, the Action Agencies¹ will promptly notify the Services.

The co-lead agencies will not incorporate comments received during the public comment period into the BA. The co-lead agencies typically do not release biological assessments to the public because these documents are part of a consultation process with the Services that does not specifically require public involvement and may not reflect the final proposed action until later in the consultation process as coordination and clarifications occur. The co-lead agencies have chosen to append the BA to the draft EIS to provide further effects analysis for the Preferred Alternative specific 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 draft EIS and in the BA are tailored to the requirements of each regulatory process.

While the EIS analyzes effects of the alternatives on all resources, and compares these and the Preferred Alternative to the No Action Alternative, the BA examines the effects of the proposed action, consistent with the Preferred Alternative, on ESA-listed species and designated critical habitat. The proposed action can be found in Chapter 2 of the BA. The effects analysis can be found in Chapter 3 of the BA.

Under the ESA, the Action Agencies must develop an analysis of the effects of the action sufficient to allow the USFWS and NMFS to determine whether the action will jeopardize the continued existence of an ESA-listed species or destroy or adversely modify designated critical habitat. This effects analysis can be found in Chapter 3 of the BA.

¹ In the EIS, the U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration are referred to as the “co-lead agencies”, consistent with NEPA terminology. In the Biological Assessment, these agencies are referred to as the “Action Agencies”, consistent with ESA terminology.

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Biological Assessment of Effects of the Operations and Maintenance of the Federal Columbia River System on ESA-Listed Species

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

January 2020

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ABBREVIATIONS AND ACRONYMS

Item	Description
Action Agencies	U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and Bonneville Power Administration
AEM	Action Effectiveness Monitoring
AFD	Albeni Falls Dam
AIF	Adaptive Implementation Framework
AMIP	Adaptive Management Implementation Plan
BA	Biological Assessment
BiOp	Biological Opinion
BON	Bonneville Lock and Dam
Bonneville	Bonneville Power Administration
BRT	Biological Review Team (NMFS)
CBP	Columbia Basin Project
CCT	Colville Confederated Tribes
CEERP	Columbia Estuary Ecosystem Restoration Program
cfs	cubic feet per second
CHaMP	Columbia Habitat Monitoring Protocol
CHARTs	Critical Habitat Analytical Review Teams (NMFS)
CHRU	Columbia Headwaters Recovery Unit
CHSU	critical habitat sub-unit
CHU	Critical Habitat Unit
COMPASS model	Comprehensive Passage Model
Corps	U.S. Army Corps of Engineers
Council	Northwest Power and Conservation Council
CR	Columbia River
CRFM	Columbia River Fisheries Management
CRITFC	Columbia River Inter-Tribal Fish Commission
CRS	Columbia River System
CRSO EIS	Columbia River System Operations Environmental Impact Statement
CSS	Comparative Survival Study
CTC	Chinook Technical Committee
CTCR	Confederated Tribes of the Colville Reservation
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DART	data access in real time
DCCO	double-crested cormorant
DIP	demographically independent population
DO	dissolved oxygen
DPS	distinct population segment
EFH	essential fish habitat
EIS	environmental impact statement

Item	Description
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
FFRAG	Fish Flow Release Advisory Group
FL	fork length
FMO	foraging, migration, and overwintering
FOG	floating orifice gate
FOP	Fish Operations Plan
FPC	Fish Passage Center
FPE	Fish Passage Efficiency
FPIP	Flow Plan Implementation Protocol
FPP	Fish Passage Plan
FPOM	Fish Passage Operations and Maintenance
FRM	flood risk management
FSOA	Flexible Spill Operations Agreement
FSWG	Flexible Spill Working Group
FWPO	flexible winter power operations
GBT	gas bubble trauma
HCP	habitat conservation plan
HIP	Habitat Improvement Program
HMP	Habitat Management Plan
IAPMP	Inland Avian Predation Management Plan
ICF	initial controlled flow
ICTRT	Interior Columbia Technical Recovery Team
IDFG	Idaho Department of Fish and Game
IFP	improved fish passage
IRA	Integrated Rehabilitation Assessment
ISAB	Independent Scientific Advisory Board
ITS	incidental take statement
I&C	implementation and compliance
JBS	juvenile bypass system
JWKIII	John W. Keys III Pump/Generating Plant
KRWS	Kootenai River white sturgeon
LAA	likely to adversely affect
LCM	Life Cycle Model
LCR	Lower Columbia River
LCRE	Lower Columbia River Estuary

Item	Description
LCREP	Lower Columbia River and Estuary Partnership
LGR	Lower Granite Dam
LRISRP	Lake Roosevelt Incremental Storage Release Project
LSRCP	Lower Snake River Compensation Plan
LWD	large woody debris
MCN	McNary Lock and Dam
MCRU	Mid-Columbia Recovery Unit
M&E	monitoring and evaluation
MAF	million acre-feet
MAT	minimum abundance threshold
MCE	minimum control elevation
MCR	Mid Columbia River
MFWP	Montana Department of Fish, Wildlife, and Parks
MIP	minimum irrigation pool
MOA	Memorandum of Agreement
MOP	minimum operating pool
MPG	major population group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
MW	megawatts
NAA	No Action Alternative
NCC	Northern California Current
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Corporation (NERC)
NFH	National Fish Hatchery
NLAA	not likely to adversely affect
NMFS	National Marine Fisheries Service
NPCC	Northwest Power and Conservation Council
NPGO	North Pacific Gyre Oscillation
NPMP	Northern Pikeminnow Management Program
NPT	Nez Perce Tribe
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
O&M	operations and maintenance
ONI	Ocean Niño Index
OPIH	Oregon Production Index, Hatchery
PBT	persistent bioaccumulative toxics
PDO	Pacific Decadal Oscillation
PIT	passive integrated transponder
PNNL	Pacific Northwest National Laboratory
PSH	pumped storage hydropower
PTAGIS	PIT Tag Information System

Item	Description
PUD	Public Utility District
Reclamation	U.S. Bureau of Reclamation
RIOG	Regional Implementation Oversight Group
RM	river mile(s)
RM&E	research, monitoring, and evaluation
RMJOC	River Management Joint Operating Committee
RPA	Reasonable and Prudent Alternative
R/S	returns-per spawner
SARs	smolt-to-adult (return) ratio
SCT	System Configuration Team
Services	U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), collectively known as the Services
SHLA	streaked horned larks
SKQ	Séliš Ksanka Qlispé Dam
SMP	Smolt Monitoring Program
SR	Snake River
SRB	Snake River Basin
SRKWs	Southern Resident killer whales
SRWG	Studies Review Work Group
T:B	transport-bypass ratio
TDG	total dissolved gas
THSC	Tributary Habitat Steering Committee
TIR	transport in-river ratio
TMDL	total maximum daily load
TMT	Technical Management Team
TRT	Technical Recovery Team
TSW	temporary spill weir
UCR	Upper Columbia River
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
VBS	vertical barrier screen
VDL	variable draft limit
VSP	viable salmonid population
WAC	Washington Administrative Code
WCM	Water Control Manual
WDFW	Washington Department of Fish and Wildlife
WMP	Water Management Plan

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1 INTRODUCTION

The U.S. Army Corps of Engineers (Corps), U.S. Bureau of Reclamation (Reclamation), and Bonneville Power Administration (Bonneville) (termed the Action Agencies) jointly manage the operation and maintenance of 14 federal multiple-use dam and reservoir projects in the Columbia River System (CRS)¹ as a coordinated water management system (Figure 1-1; Appendix A). In collaboration with federal and state agencies, tribal sovereigns, public and private utilities, and various stakeholders, the Action Agencies implement a suite of coordinated actions at both the system and project levels to manage the CRS.

Under Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. § 1536(a)(2) 1973), the Action Agencies are responsible for ensuring that their actions are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of designated critical habitat. To ensure that the Agencies' operation and maintenance of the system (referred to herein as system management) complies with the ESA, the Agencies are providing this Biological Assessment (BA) describing (1) the Proposed Action (i.e., operations, maintenance, and non-operational conservation measures), (2) an analysis of the effects of the Proposed Action on ESA-listed species and designated critical habitat, and (3) conclusions with supporting rationale for determination of impacts from the Proposed Action on ESA-listed species and designated critical habitat.

1.1 ESA CONSULTATION

1.1.1 Request for Formal Consultation

The Action Agencies prepared this BA for the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), collectively known as the Services. This BA reinitiates formal consultation on the effects of CRS management on ESA-listed species and designated critical habitat. This BA also initiates consultation with NMFS on the effects of the CRS on essential fish habitat under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. § 1855(b) 1976). This BA supersedes the 2016 BA used to initiate formal consultation with USFWS by updating the action, effects analysis, and mitigation measures proposed for resident ESA-listed species to account for new information. These consultations are to be conducted using the standard ESA jeopardy analysis. This is a full BA [per Title 50 of the *Code of Federal Regulations* Part 402 (50 CFR 402 1973)] addressing listed species affected by the CRS and under the jurisdiction of the Services (Table 1-1.).

¹ In past consultations, the Action Agencies used the term Federal Columbia River Power System (FCRPS) to refer the coordinated operation of 14 specific federal projects in the Columbia River Basin. These 14 federal projects, however, are a subset of the 31 federal projects that compose the FCRPS. The name change is meant to eliminate past confusion and clarify that this BA focuses on the 14 CRS projects. The Corps owns and operates 12 projects in the CRS: Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Dworshak, Chief Joseph, Albeni Falls, and Libby Dams. Reclamation owns and operates two projects: Grand Coulee and Hungry Horse Dams. Reclamation also operates the Columbia Basin Project and other irrigation projects.

This consultation covers the effects of the Proposed Action for operation, maintenance, and associated non-operational conservation measures for the 14 CRS dams for a timeframe of fifteen years. The Action Agencies have selected this timeframe due to the currently anticipated time necessary to conduct a study that will assess the magnitude of latent mortality associated with juvenile salmonid passage through the CRS dams. Additionally, the consultation addresses the mainstem effects of several tributary irrigation projects not coordinated with the CRS (see Appendix C). The effects of these water withdrawals are included as a matter of convenience,² because the withdrawals are integrated into the hydrologic models used for analyses in the CRS environmental impact statement (EIS) and ESA processes. This BA focuses on the Proposed Action's effects on ESA-listed fish species (Table 1-1), but also provides high-level discussion of effects on other ESA-listed species. Also covered are system management actions to support the reliability of the federal transmission system in compliance with statutory and regulatory requirements (see Appendix B).

² While not required by the ESA or the ESA regulations, Reclamation has chosen, as a matter of administrative convenience, to include the effects of mainstem water withdrawals of tributary irrigation projects in this single biological assessment as permitted by 50 CFR 402.14(c).

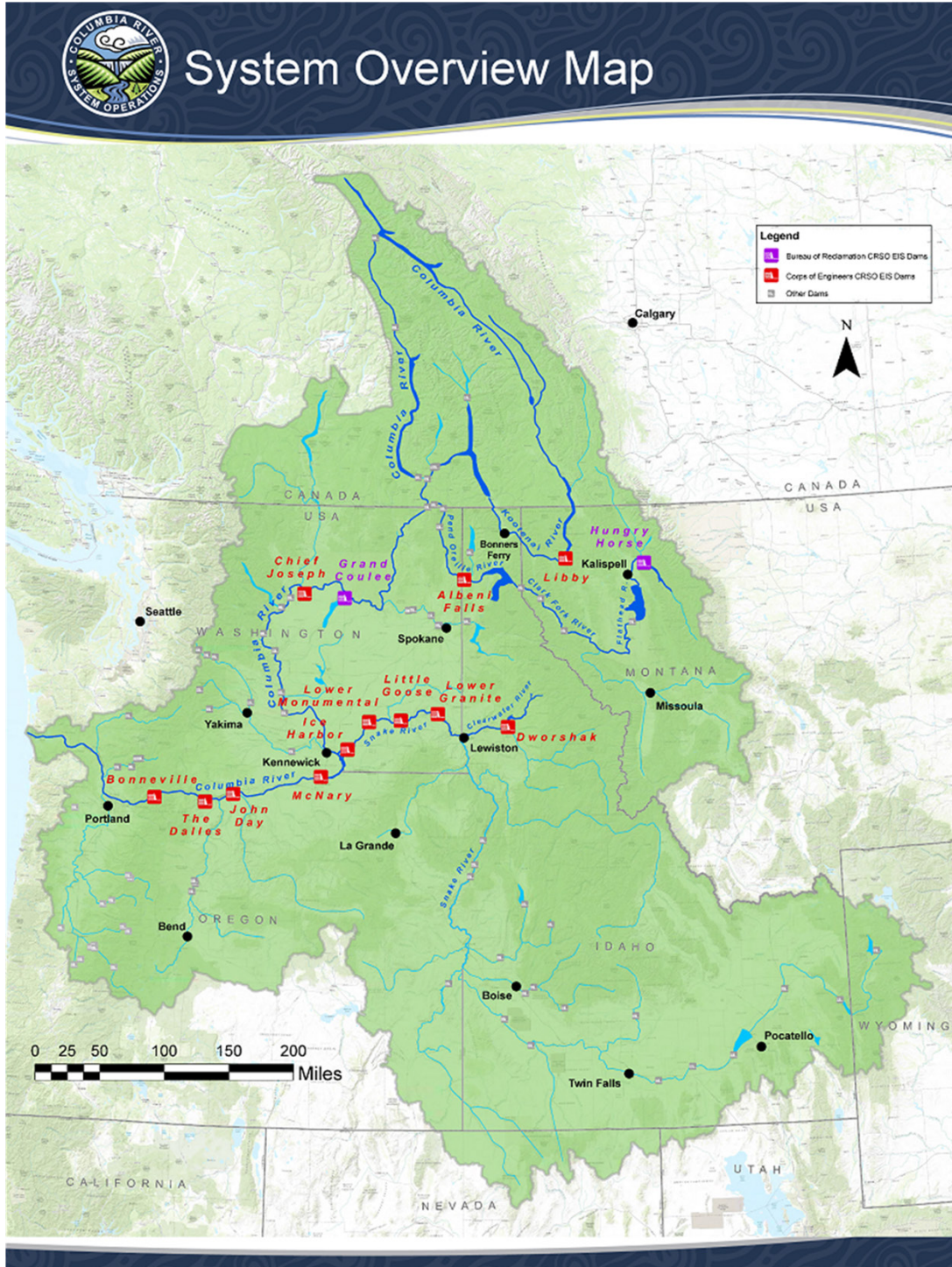


Figure 1-1. Map of the Columbia River Basin showing the 14 CRS projects subject to the ESA Section 7 consultation

Table 1-1. Federally listed species, status, designated critical habitat, and Action Agency determination in the proposed CRS action area

ESA-Listed Species	ESA Listing Status	ESA Critical Habitat Designated?	Action Agency Determination
Interior Columbia River Basin Salmonid Species			
Bull trout	Threatened	Yes	LAA ^a
Snake River (SR) fall Chinook salmon ESU	Threatened	Yes	LAA
SR spring/summer Chinook salmon ESU	Threatened	Yes	LAA
SR steelhead DPS	Threatened	Yes	LAA
Upper Columbia River (UCR) spring Chinook salmon ESU	Endangered	Yes	LAA
UCR steelhead DPS	Threatened ^b	Yes	LAA
Middle Columbia River steelhead DPS	Threatened	Yes	LAA
SR sockeye salmon ESU	Endangered	Yes	LAA
Lower Columbia Basin Salmonid Species			
Columbia River chum salmon ESU	Threatened	Yes	LAA
Lower Columbia River (LCR) Chinook ESU	Threatened	Yes	LAA
LCR coho salmon ESU	Threatened	Yes	LAA
LCR steelhead DPS	Threatened	Yes	LAA
Upper Willamette River (UWR) Chinook salmon ESU	Threatened	Yes	LAA
UWR steelhead DPS	Threatened	Yes	LAA
Non-Salmonid Species			
Columbian white-tailed deer	Threatened	No	NLAA ^a
Grizzly bear	Threatened	Yes	NLAA
Kootenai River white sturgeon	Endangered	Yes	LAA
Southern resident killer whale	Endangered	Yes ^c	NLAA
Southern DPS green sturgeon	Threatened	Yes	NLAA
Southern DPS eulachon	Threatened	Yes	LAA
Ute ladies'-tresses	Threatened	No	NLAA
Yellow-billed cuckoo	Threatened	Proposed	NLAA
Streaked horned lark	Threatened	Yes	NLAA

^a LAA = likely to adversely affect; NLAA = not likely to adversely affect.

^b Reclassified from Endangered to Threatened (71 FR 834 2006)

^c Proposed for revision (84 FR 49214 2019)

1.1.2 Consultation History

1.1.2.1 FWS Consultations

The Action Agencies have consulted with the USFWS on the effects of the CRS operations on ESA-listed resident fish species since 1995 (Figure 1-2). These consultations began after the listing of the Kootenai River white sturgeon in 1994 (59 FR 45989 1994), followed by bull trout in 1998 (63 FR 31647). In 2000, the USFWS issued a biological opinion (BiOp) for the effects of CRS operations and maintenance on Kootenai River white sturgeon and bull trout (USFWS 2000). In 2003, the Libby Dam operation was challenged in the U.S. District Court of Montana by the Center for Biological Diversity and WildWest Institute, which resulted in a Kootenai River white sturgeon critical habitat designation for publication in the Federal Register as of February 8, 2006. In response to this designation, the Corps reinitiated ESA consultation in 2003, and the USFWS issued a new BiOp on February 18, 2006 (USFWS 2006), which considered the effects of the proposed operation of Libby Dam on the endangered Kootenai River white sturgeon, its designated critical habitat, and bull trout. The plaintiffs filed an amended complaint, and the parties entered into a settlement agreement as of September 2, 2008, whereby the USFWS issued a clarified Reasonable and Prudent Alternative (RPA) on December 29, 2008, specific to the effects of Libby Dam operations on ESA-listed species. The 2000 Federal Columbia River Power System (FCRPS) and 2006 supplemental Libby BiOps are the most current USFWS BiOps in effect for CRS operations and will remain in effect until completion of the current request for consultation (NMFS 2000; USFWS 2006).

1.1.2.2 NMFS Consultations

The Action Agencies have also consulted with NMFS about the effects of the CRS operations on ESA-listed anadromous fish species in the Columbia River Basin, beginning with the listing of SR sockeye salmon in November 1991 (Figure 1-2.). Since then, NMFS has issued 11 BiOps or supplemental BiOps on system management. Most were challenged in federal court and subsequently modified on remand with new analyses and conservation measures.

Most recently, in May 2016, the United States District Court for the District of Oregon invalidated NMFS' 2008 FCRPS BiOp, as supplemented in 2010 and 2014. The court held that NMFS did not provide an adequate explanation for its analysis in the BiOp that FCRPS operations and maintenance were not likely to jeopardize the continued existence of ESA-listed salmon and steelhead species. The court ordered continued implementation of the 2014 supplemental BiOp while NMFS prepared a new BiOp. Although the court subsequently modified the remand deadline for a new BiOp to a later date, the Action Agencies consulted with NMFS on an interim action resulting in the 2019 NMFS CRS BiOp (NMFS 2019). It included an innovative system operation called flex spill, designed to optimize the tradeoff between spill operations intended to benefit juvenile salmon and steelhead spring outmigration and the production of hydropower, while ensuring that the Corps is able to implement the operation in accordance with the Congressionally authorized purposes of the projects (see Chapter 2, Proposed Action for details).

The 2019 NMFS CRS BiOp found that operation and maintenance of the CRS was not likely to jeopardize ESA-listed salmon and steelhead species and is in effect until the Records of Decision are signed for the Columbia River System Operations (CRSO) EIS and associated consultations under the ESA (NMFS 2019).

In addition, the 2016 court ruling found that the National Environmental Policy Act (NEPA) (42 U.S.C. §§ 4321 et seq. 1969) coverage for CRS operations was inadequate. The court ordered the Action Agencies to conduct comprehensive NEPA analysis of CRS operations. The proposed future operations, maintenance, and mitigation measures analyzed for the CRSO EIS will be detailed for the Preferred Alternative in the CRSO Draft EIS (DEIS).³ The BA's Proposed Action will be consistent and aligned with the DEIS Preferred Alternative. The existing 2019 BiOp will remain in effect until completion of the current request for consultation.

³ The Action Agencies are scheduled to issue the draft CRSO EIS in February 2020.

CRS Biological Assessment

Major ESA - Consultation Events Involving Operation of the Federal Columbia River Power System (FCRPS)

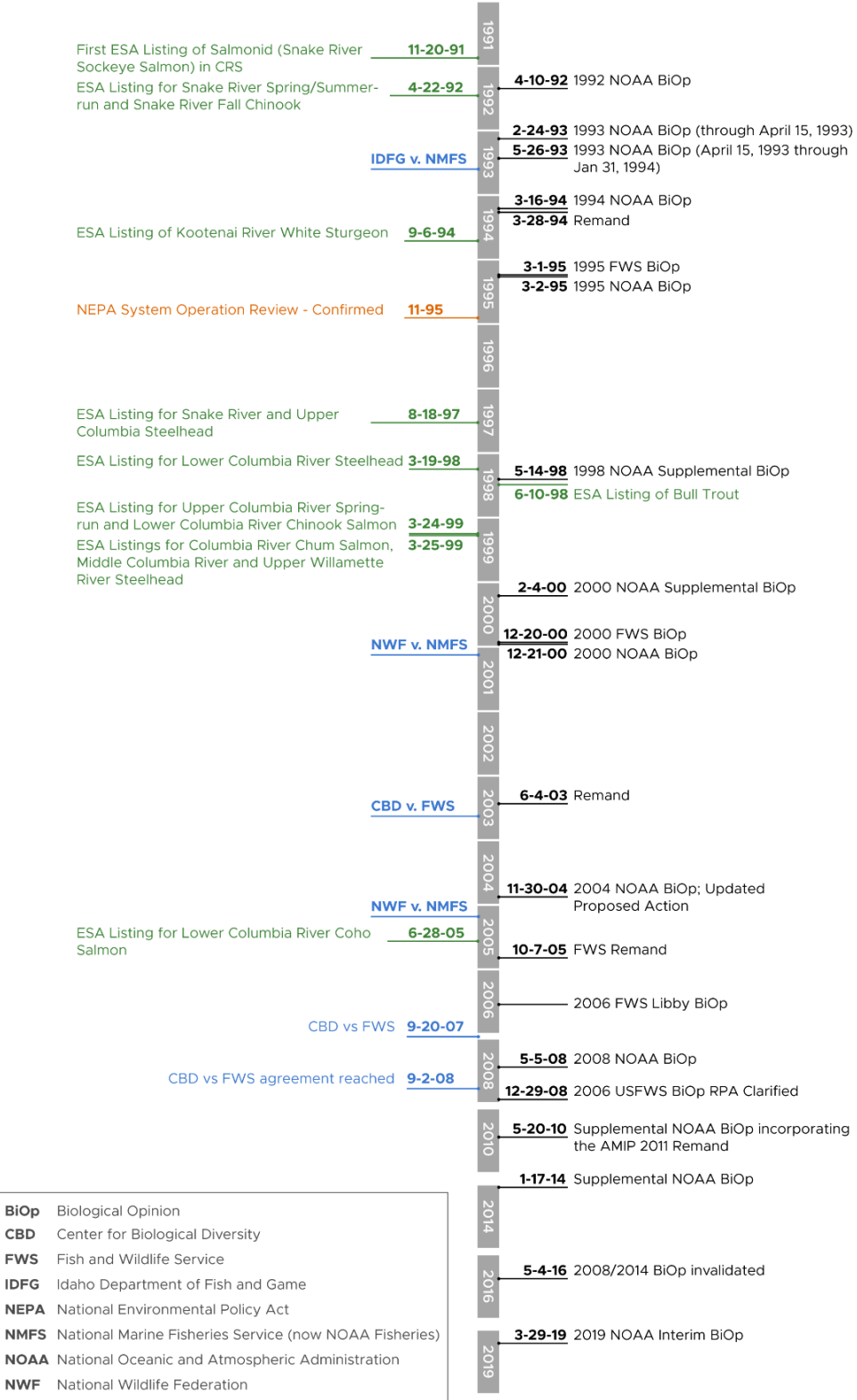


Figure 1-2. Timeline for ESA-related events for the Columbia River System

1.1.3 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 1973). For this consultation, the action area for all anadromous and resident aquatic species is as follows:

- the Columbia River from the Canadian border to and including the lower Columbia River, estuary, and ocean plume;
- the Kootenai River including and downstream of Libby Dam and the U.S. portion of the reservoir;
- the Flathead River including and downstream of Hungry Horse Dam and Reservoir;
- the Snake River starting 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.

The action area also includes subbasins that are the focus of the tributary habitat improvement actions that the Action Agencies have proposed to offset any continuing adverse effects of system management. Further, the action area extends upstream to all spawning and rearing areas accessible to ESA-listed species affected by the CRS action. The downstream extent of the action area for fish species is the plume in the nearshore Pacific Ocean immediately adjacent to the river mouth, as defined by observable changes in water conditions attributable to CRS operations.

The action area for Southern Resident killer whales is inclusive of all areas off the Pacific Coast where salmonid species from the Columbia River, which are affected by CRS operations, are available as prey for listed Southern Resident killer whales. This area encompasses the whales’ entire coastal range from the Columbia River’s mouth and plume south to southern Oregon and north to the Queen Charlotte Islands.

1.2 BACKGROUND

The Columbia River originates in Canada and flows for more than 1,200 miles before emptying into the Pacific Ocean. The river drains about 219,000 square miles in the United States and about 39,500 square miles in Canada. At the direction of Congress, the Corps and Reclamation developed comprehensive plans for managing the water resources of the Columbia River Basin (33 U.S.C. 701 1950; Public Law 87-874 1962). Numerous dams—federal, public, and private—have been built in the basin for flood control,⁴ hydropower generation, navigation, recreation, irrigation, and municipal and industrial water supply. Specifically, the CRS includes six storage projects for capturing water to manage flood risk, as well as generate hydropower, irrigate agricultural lands, etc. In addition, the CRS has eight run-of-river projects on the mainstem lower Columbia and Snake rivers that provide hydropower generation and navigation from the mouth of the Columbia River to Lewiston, Idaho.

⁴ The Corps has adopted the terminology *flood risk management* (FRM) rather than *flood control* to assist the public in understanding that flood events cannot always be controlled or prevented. Flood risk management or FRM will be used hereafter.

An important factor affecting system management in the CRS is the relatively small percentage of annual runoff that can be stored in CRS reservoirs. Of the annual average of about 200 million-acre-feet (MAF) of runoff, only about 20 percent can be stored. This generally means that operators cannot use stored water to transform a dry year's water supply into an average flow year. Limited storage capacity and variability of hydrologic conditions in the Columbia River Basin are among many factors the Action Agencies consider for effectively managing the river and its resources.

1.3 COORDINATION

Many groups and teams are integral to informing fish operations of the CRS. Representatives can include staff from the Corps, Bonneville, Reclamation, USFWS, NMFS, IDFG, WDFW, ODFW, MFWP, and Columbia Basin Tribes such as the Confederated Bands and Tribes of the Yakama Nation, the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Colville Reservation, the KTOI, and others.

Operation of the CRS is complex and requires extensive coordination to meet multiple authorized purposes and statutory responsibilities. Congress authorized specific CRS project purposes and directed the Corps and Reclamation to determine how best to serve these purposes and address the needs of any competing interests. The project purposes are interdependent; operating for one purpose can affect one or more others. For example, releasing storage water from the reservoir above Hungry Horse Dam for flow augmentation to benefit downstream fish species could affect habitat availability in the reservoir for resident species.

Another factor contributing complexity to system management is the Columbia River Treaty (1961). Under the treaty, the U.S. and Canadian governments agree to address the international aspects of managing transboundary waters by coordinating operations for FRM and hydropower generation for both countries' beneficial use.

The Action Agencies coordinate CRS operations with Canada and non-federal project operators, such as the Mid-Columbia public utility districts⁵ and private utilities. The Action Agencies also consult with sovereigns⁶ consistent with existing agreements, relevant laws, and treaties, working collaboratively with sovereign parties to address the implementation of CRS operations related to anadromous and resident fish species through various policy and technical teams of the Regional Forum. Through the Regional Forum process, the Action Agencies coordinate CRS operations through a given water year, considering how best to manage in-season conditions for ESA-listed anadromous and resident fish species. Chapter 2 includes a more detailed discussion of the Regional Forum and coordination efforts.

⁵ Three public utility districts from the State of Washington (Douglas, Chelan and Grant counties) own five mid-Columbia dams - Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids. The PUDs plan and coordinate their operations with the federal agencies.

⁶ Sovereign is used here to denote representatives from governments at the federal, state, and tribal levels.

1.4 RELATIONSHIP TO THE CONCURRENT NEPA PROCESS

The proposed future operations, maintenance, and non-operational measures that are the subject of this BA and request for consultation are being analyzed through the CRSO EIS process to comply with NEPA. The Proposed Action described in Chapter 2 of this BA considers the need to integrate multiple Congressionally authorized project purposes and is consistent with the Preferred Alternative detailed in the CRSO DEIS.

1.5 CONTENTS

This BA includes a description of the Proposed Action (Chapter 2), a global factors and effects analysis (Chapter 3), and a summary and Conclusion (Chapter 4). Appendices include CRS project authorizations and descriptions (Appendix A); actions taken by Bonneville in managing the federal transmission system that can influence water management actions consulted on in this BA (Appendix B); Columbia River mainstem depletions associated with Reclamation irrigation projects (Appendix C); a supplemental narrative for tributary habitat actions (Appendix D); and an updated summary of CRS operational and structural measures to benefit fish (Appendix E). This BA demonstrates the relationship between species status, effects of the Proposed Action, and determination of impacts, thereby supporting focused and effective mitigation measures.

1.6 REFERENCES

- 42 U.S.C. §§ 4321 et seq. 1969. *National Environmental Policy Act of 1969, as amended*. Public Law 91-190. US Code. January 1, 1970.
- 16 U.S.C. § 1536(a)(2). 1973. *Endangered Species Act of 1973, as amended*. Public Law 93-205. US Code. 1973.
- 16 U.S.C. § 1855(b). 1976. *Magnuson-Stevens Fishery Conservation and Management Act*. Public Law 94-265. US Code. April 13, 1976.
- 33 U.S.C. 701. 1950. *Flood Control Act of 1950*. Public Law 81-516. May 17, 1950.
- 50 CFR 402. 1973. "Wildlife and Fisheries: Endangered Species Act of 1973, as Amended." Code of Federal Regulations.
- 50 CFR 402.02. 1973. "Definitions (Wildlife and Fisheries: Endangered Species Act of 1973, as Amended)." Code of Federal Regulations.
- 59 FR 45989. 1994. "Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Kootenai River Population of the White Sturgeon." *Federal Register* 59(171):45989. Department of the Interior, Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-1994-09-06/html/94-21864.htm>.
- 63 FR 31647. 1998. "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Klamath River and Columbia River Distinct Population Segments of Bull Trout." *Federal Register* 63(111):31647-31674. Available at <https://www.govinfo.gov/content/pkg/FR-1998-06-10/pdf/98-15319.pdf>.
- 71 FR 834. 2006. "Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead." *Federal Register*:834-862. U.S Department of

Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.federalregister.gov/documents/2006/01/05/06-47/endangered-and-threatened-species-final-listing-determinations-for-10-distinct-population-segments>.

84 FR 49214. 2019. "Endangered and Threatened Wildlife and Plants; Proposed Rulemaking To Revise Critical Habitat for the Southern Resident Killer Whale Distinct Population Segment." *Federal Register* 84(182):49214-49235. National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce. Available at <https://www.govinfo.gov/content/pkg/FR-2019-09-19/pdf/2019-20166.pdf>.

15 U.S.T. 1555; U.N.T.S. 244. 1961. "Treaty Relating to Cooperative Development of the Water Resources of the Columbia River Basin (with Annexes)." January 17, 1961. [Hereinafter Columbia River Treaty.] The Treaty was signed by the United States in 1961, but was not ratified in British Columbia until 1964. Available at <http://extwprlegs1.fao.org/docs/pdf/bi-145062.pdf>.

NMFS. 2000. *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*. Washington, D.C.: NOAA Fisheries, Northwest Region. December 21, 2000.

NMFS. 2019. *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*. Portland, OR: NOAA Fisheries, West Coast Region. NMFS Consultation No. WCRO-2018-00152. Available at https://www.westcoast.fisheries.noaa.gov/publications/hydropower/fcrps/master_2019_crs_biological_opinion_1.pdf.

76 Stat. 1195. 1962. *Flood Control Act of 1962*. Public Law 87-874. October 23, 1962.

USFWS. 2000. *BIOLOGICAL OPINION: Effects to Listed Species From Operations of the Federal Columbia River Power System*. Washington, D.C.: U.S. Fish and Wildlife Service (USFWS). December 20, 2000.

USFWS. 2006. *Biological Opinion Regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat*. Washington, D.C.: U.S. Fish and Wildlife Service (USFWS). February 18, 2006. Available at <https://www.salmonrecovery.gov/Files/BiologicalOpinions/2008/Final%20Libby%20Dam%20BiOp%202-18-06lr3.pdf>.

2 PROPOSED ACTION

This chapter contains the Proposed Action for the 2019 Biological Assessment of CRS operations and maintenance (system management). The core of the Proposed Action is coordinated CRS water management to meet the federal agencies' authorized purposes, including flood risk management, irrigation, navigation, hydropower generation, fish and wildlife conservation, recreation, and water supply (agricultural, industrial and municipal).¹ In addition, CRS water management actions to support the reliability of the federal transmission system are included in the Proposed Action (described further in Appendix B). The Proposed Action, system operations (Section 2.3), maintenance (Section 2.4), structural measures to benefit Pacific lamprey (Section 2.5), non-operational conservation measures to benefit ESA-list species (Section 2.6), and monitoring, reporting, and regional coordination (Section 2.7).

Through the CRSO National Environmental Policy Act (NEPA) process, several changes to CRS management from previous consultations were incorporated into the CRSO EIS referred Alternative. These changes in turn have been incorporated into the proposed action for the CRS BA. Refer to the CRSO EIS for a detailed explanation of the Preferred Alternative.

2.1 REGIONAL COORDINATION

The Action Agencies will coordinate the implementation of the proposed action through the established Regional Forum and other existing regional work groups and processes. This will allow the Action Agencies to maintain open dialogue and communication among federal, state and tribal sovereigns while intentionally linking science and new learnings to inform management actions and policy decisions.

2.1.1 Regional Forum

The Action Agencies will continue regional coordination of CRS water management/reservoir regulation, fish passage operations and maintenance activities, fish passage capital improvements and related research, monitoring, and evaluations (RM&E) through the established Regional Forum. The Regional Forum is a system of interacting technical work groups that operate under the direction of the Regional Implementation and Oversight Group (RIOG) (Figure 2-1). The purpose of the Regional Forum is to provide venues for NMFS, USFWS and other regional sovereigns to inform Action Agency decision regarding CRS operations and configurations related to fish.

Regional Forum technical work groups meet routinely throughout the year and provide a predictable framework of governance structure (Table 2-1). At routine meetings and in other communications, designated representatives from NMFS, USFWS, and other regional sovereigns provide technical feedback on Action Agency products or actions, collaborate on development of planning documents (e.g., the annual Fish Passage Plan or FPP), and identify issues that need policy guidance or decision at a higher level (i.e., RIOG).

¹ The Congressionally authorized project purposes may vary by project.

Plans developed and reviewed at various levels of the Regional Forum guide CRS operations through a given water year, taking into account how best to manage conditions for the benefit of both ESA-listed resident and anadromous fish species, as well as other species of concern. To assist on informing in-season coordination decisions, the Action Agencies monitor and report near-real-time environmental conditions at all CRS projects, including river flows, river temperatures, and total dissolved gas (TDG) monitoring at all FCRPS projects, and adult and juvenile fish passage and transportation at lower Snake and Columbia River projects.

The Action Agencies also operate the CRS in coordination with several public utility districts (on the middle Columbia River, the Snake River, and other tributaries), and with three Canadian projects pursuant to the Columbia River Treaty between the United States and Canada.

The Action Agencies also operate the CRS in coordination with several public utility districts (on the middle Columbia River, the Snake River, and other tributaries), and with three Canadian projects pursuant to the Columbia River Treaty between the United States and Canada.

Regional Forum Work Group Coordination

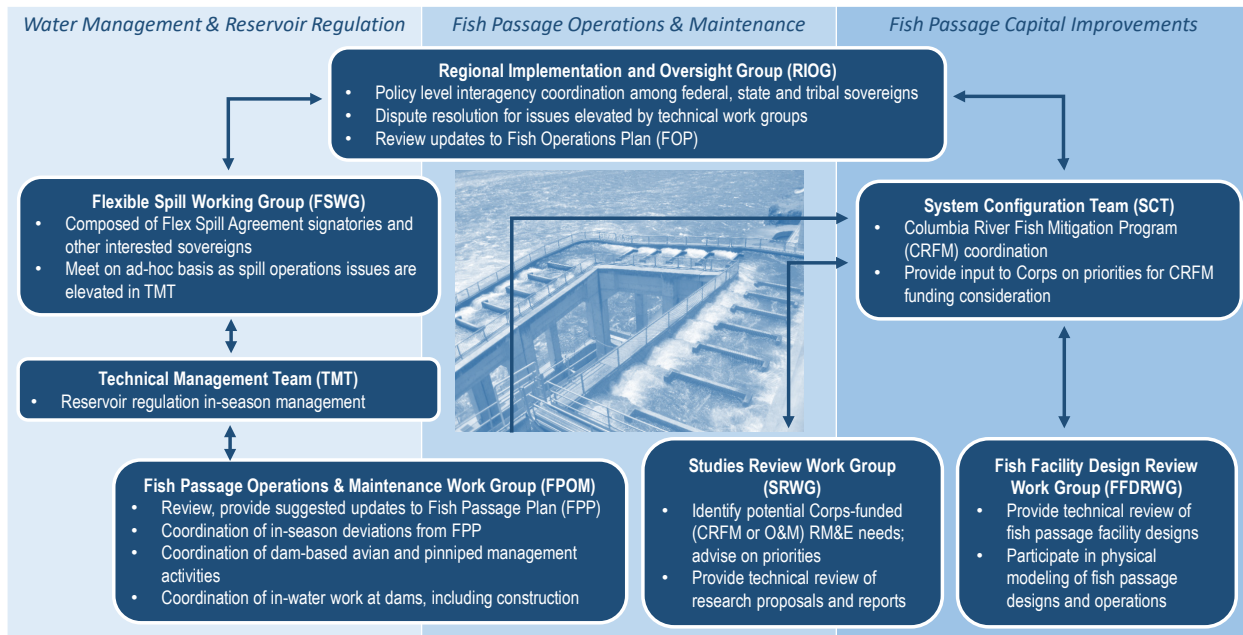


Figure 2-1. Regional Forum coordination working groups and teams inform Action Agency actions related to water management and reservoir regulation, fish passage, operations and maintenance, and capital improvements

Table 2-1. Typical meeting cadence and key milestones for Regional Forum work groups

Regional Forum	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
RIOG	Review FOP (Appendix of FPP) / Meet quarterly or ad-hoc to address elevated topics from FSWG, TMT, or other work groups												
FSWG	Meet ad-hoc based on elevated topics from TMF												
TMT	Meet weekly to bi-weekly as needed												
	Finalize WMP									Prepare WMP			
SCT	Meet monthly to provide input on CRFM (Corps) program priorities, incl. fish passage improvements and RM&E												
SRWG	Review and develop research objectives for Corps-funded RM&E				Advise Corps on Priorities	Review research proposals and scopes of work					Annual Review		
FPOM	Finalize FPP, incl. FOP									Prepare FPP, incl. FOP			
	Meet monthly to monitor project O&M, incl. deviations from the FPP and FOP												
FFDRWG	Meet Quarterly (or ad-hoc) to review and discuss fish passage improvement designs												

2.1.1.1 Regional Implementation Oversight Group (RIOG)

The RIOG was established to provide a policy level interagency coordination forum for discussion and coordination of the operations and maintenance of the CRS by regional sovereign representatives. The RIOG and technical sub-teams include representatives from federal agencies, tribes, and states. The overall purpose of the group is to inform the federal, state, and tribal sovereigns that are actively engaged in efforts to benefit both anadromous and resident species regarding implementation issues from each sovereign’s perspective. The RIOG is the highest policy level, Regional Forum workgroup and engages during key decision milestones (e.g., Water Management Plan guidance) or to assist with resolution of issues elevated by technical work groups.

2.1.1.2 Flexible Spill Working Group (FSWG)

Building off the success and momentum achieved through the 2019–2021 Spill Operation Agreement, Action Agencies encourage and support the continuation of the collaborative Flexible Spill Working Group (FSWG). The FSWG was established in 2017 by state, federal and tribal policy advisors and technical experts to establish an operation that would provide fish benefits, flexibility for power revenue and reliability as well, and an operation feasible for the multi-purpose hydrosystem. The FSWG shall, at a minimum, include a representative from each signatory to the Agreement. Other regional sovereigns, not signatories to the 2019–2021 Spill Operation Agreement, would be invited to join and participate in future operation and study designs. The intent of this group is to complement existing Regional Forums.

In instances where members of the Technical Management Team (TMT) are not able to resolve a spill operations related issue to the satisfaction of all parties, the FSWG will meet and advise on outcomes for the Corps to implement without requiring further dispute resolution. If the FSWG cannot resolve the issue without objection, the issue shall be elevated to RIOG for resolution. The FSWG is proposed to meet as needed, based on the needs of TMT.

2.1.1.3 Technical Management Team (TMT)

The TMT mission is to develop recommendations from sovereign representatives to the Action Agencies on a variety of in-season operations to benefit fish, including spill, temperature, and flows as outlined in the BiOps for ESA-listed salmon, steelhead, sturgeon, and bull trout species within the Columbia River Basin, while taking into account the needs of (and effects on) other listed and non-listed species (such as lamprey). The TMT serves as a forum for broad technical participation and use of the best available technical information for in-season reservoir operations and management. For example, the Kootenai River Flow Plan Implementation Protocol Technical Team and Fish Passage Operations and Maintenance (FPOM) report to, and make recommendations for in-season reservoir management to the TMT. The TMT meets weekly to bi-weekly as needed.

2.1.1.4 System Configuration Team (SCT)

The System Configuration Team (SCT) is the Regional Forum venue through which the Corps coordinates and receives feedback on the Columbia River Fish Mitigation Program (CRFM). Projects funded through CRFM generally include structural improvements to fish passage facilities and RM&E designed to inform decisions regarding structural or operational changes at the Corps' lower Columbia and lower Snake River dams. Other CRFM-funded projects include certain estuary habitat restoration and avian predation management actions and studies. In SCT meetings, the CRFM program manager provides budget/cost updates and briefs participants on implementation of projects, and solicits feedback from regional sovereigns on program priorities. Other work groups, such as SRWG or FPOM, periodically refer new identified needs for consideration to the CRFM Program Manager via SCT meetings. The SCT typically meets monthly.

2.1.1.5 Studies Review Work Group (SRWG)

The SRWG is a technical work group that advises the Corps regarding applied scientific RM&E studies to inform and/or evaluate operational or structural changes at lower Columbia and lower Snake River dams. The SRWG also reviews and informs RM&E associated with the Corps' estuary habitat restoration and avian predation management studies. Collectively, this program of Corps-funded studies is referred to as the Anadromous Fish Evaluation Program (AFEP). SRWG representatives help the Corps develop and refine research goals/objectives, recommend priorities to the Corps, and provide technical review of products such as research proposals and reports. Other work groups, such as FPOM, may identify RM&E needs or objectives for SRWG consideration. Study needs identified and prioritized in SRWG may be referred to the SCT work group for funding consideration. While most studies were historically funded through the CRFM Program, some studies developed and reviewed by SRWG are Operations and Maintenance (O&M) funded. The SRWG meets several times throughout the year to assist the Corps in

planning studies to be conducted in the following calendar year (i.e., meetings in 2020 will be used to plan 2021 studies). Each winter, the Corps hosts the AFEP Annual Review. At the AFEP Annual Review, Corps-funded researchers and others present preliminary results from that year's studies. This informs development of research objectives for the following year.

2.1.1.6 Fish Facility Design Review Work Group (FFDRWG)

The FFDRWG provides input to the Corps' engineering and design of fish facility modifications and new passage technologies. FFDRWG representatives review design reports and plans and specifications packages and participate in the Corps' physical modeling of fish passage designs and operations. While most projects reviewed by FFDRWG include larger-scale structural modifications, small-scale or experimental fishway modifications identified or proposed through FPOM or SRWG are referred to FFDRWG for technical review. The FFDRWG is organized into two functional teams that review projects managed by the Corps' Walla Walla and Portland districts. Walla Walla and Portland District FFDRWG meetings are held at least quarterly or as needed, depending on the number of active design projects underway.

2.1.1.7 Fish Passage Operations and Maintenance Coordination Team (FPOM)

The FPOM technical work group is the venue through which the Action Agencies coordinate fish passage operations and maintenance activities with NMFS, USFWS and other regional sovereigns. During FPOM meetings, the Corps provides updates on ongoing operations or issues, solicits input on in-season management decisions, and coordinates any construction activities that may affect normal fish passage operations. FPOM representatives routinely provide input on in-season management decisions or unanticipated incidents via written responses to coordination memoranda distributed via email by the Corps. FPOM representatives annually review and suggest updates to the Corps' Fish Passage Plan (FPP) and recommends pre-season updates and in-season adjustments to the Fish Passage Plan (FPP). Seasonal operations as described in the FPP are sometimes adjusted based on new technical information or based on policy level agreements, as directed by RIOG or the FSWG. FPOM assigns representatives to task groups focused on coordination of particular topics such as pinniped predation management. FPOM may refer issues or needs to other work groups as appropriate. FPOM meets at least monthly; ad hoc meetings are sometimes held if particular issues need timely discussion and resolution.

2.1.2 Kootenai River Regional Coordination

2.1.2.1 Kootenai River Flow Plan Implementation Protocol Technical Team (FPIP)

At Libby Dam, the Kootenai River Ecosystem Function Restoration FPIP includes an FPIP technical team that develops an annual recommendation about the shape, timing, and duration of expenditure of the tiered sturgeon volume, generally during late May (but potentially commencing in early to mid-April) into early June. The FPIP team is composed of regional biologists and water managers, and is independent of the USFWS' Kootenai River White Sturgeon Recovery Team, although representation of both teams is very similar. Annual planning for Kootenai River white sturgeon flow augmentation

operations commences with preparation of a draft sturgeon flow recommendation and associated monitoring plan by the Action Agencies and the USFWS during early spring. The draft flow recommendation and monitoring plans are reviewed by the entire FPIP technical team, and then submitted to the FPIP Policy Team for review. Upon Policy Team approval, the plans are submitted to USFWS, which prepares a Systems Operation Request for Kootenai River white sturgeon flow augmentation based on the FPIP flow recommendation, and submits it to the Corps via the TMT. The Systems Operation Request is submitted and discussed in the TMT. The Corps announces how they will implement the recommendation before flow augmentation begins. The FPIP technical team holds coordination calls regularly, before and throughout the augmentation period.

2.1.2.2 Kootenai River White Sturgeon Recovery Team (KREFR)

The Kootenai River White Sturgeon Recovery Team has been in existence since 1994, shortly after the species was listed as endangered. It is an advisory group formed and chaired by the USFWS to address technical issues related to sturgeon recovery, to evaluate ongoing research and management efforts, and to make recommendations for further work. The Recovery Team developed the Kootenai River White Sturgeon Recovery Plan in 1999, which was revised in 2019. The team comprises biologists from the Seattle District of the Corps, Bonneville, USFWS, MFWP, IDFG, the KTOI, BCMFLNRO, and Cramer Fish Sciences/University of Idaho. The Recovery Team forms committees as needed to carry out specific tasks. It brings in outside expertise (a notable example is the USGS), often on contract to individual agencies or the Kootenai Tribe of Idaho, to address specific questions. Several non-members are also generally present at meetings to lend technical support to the Recovery Team's efforts.

2.2 GOVERNMENT-TO-GOVERNMENT CONSULTATION

In addition to the specific regional coordination efforts described above by the Regional Forum, the Action Agencies also engage in additional sovereign coordination with the Tribes. Consistent with the unique relationship between the federal government and federally recognized Indian tribes, the Action Agencies engage in government-to-government consultations with tribes on a case-by-case basis on a wide variety of matters, including matters related to the implementation of CRS BiOps. Government-to-government consultations can occur at the request of either a tribe or an Action Agency. Consultation is typically between the governing body of the tribe and the senior executive of the relevant Action Agency.

2.3 SYSTEM OPERATIONS

System operations for the proposed action including the management of the CRS for flood risk management (FRM), conservation of fish and wildlife, hydropower generation, irrigation and municipal and industrial water supply, navigation, recreation, and water quality are discussed in the following sections.

In the description of the operations below, hydrographs are used to illustrate seasonal operations; these plots were developed using results from a CRS system ResSim model that simulates reservoir releases and river flows over a wide variety of hydrologic conditions. The inputs used to drive the model include hydrologic datasets based on the historically observed 80-year period of record (1929 to 2008), as well

as synthetic hydrologic datasets to represent extreme winter and spring flood events. These plots group water years into “dry,” “average,” and “wet” years, based on the April to August water supply issued on May 1, then take the median flow or elevation for each day within the group. Water years are categorized with respect to the forecasted seasonal runoff volume percentile: dry years represent the lowest 20 percent, average years represent forecasts between 20 percent and 80 percent, and wet years represent forecasts greater than 80 percent (same as the highest 20 percent). The figures for Libby, Hungry Horse, and Dworshak Dams use their own local basin forecast volumes for the water year categorization. All other locations use The Dalles Dam forecast volumes for the water year categorization.

System operations for the Proposed Action including the management of the CRS for flood risk management (FRM), conservation for fish and wildlife, power generation, irrigation and municipal and industrial water supply, navigation, recreation, and water quality are discussed in the following sections.

2.3.1 Operations for Flood Risk Management

The CRS is authorized to provide FRM in the Columbia River Basin. It is the responsibility of the Corps and Reclamation to protect the general safety and welfare of the public by managing risks and consequences associated with flooding. The Corps and Reclamation operates storage dams and reservoirs to balance inflow and outflow and meet the authorized purposes. The system includes storage reservoirs in the upper Columbia and Snake River Basins (Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak), as well as a series of levees and run-of-river dams (Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville) in the middle and lower Columbia River Basin operated to meet multiple project purposes. John Day Dam, located on the lower Columbia River, has some limited storage space, but is generally operated as a run-of-river project rather than a storage project. All CRS storage projects generally operate in a coordinated manner to minimize flood consequences in local areas and in the lower Columbia River below Bonneville Dam. Operations are developed collaboratively by Action Agency water managers and are described in the Water Control Manual (WCM) for most projects. Operations may vary from year to year based on forecasted water conditions and are adjusted throughout the year to meet changing conditions caused by weather. A gage located at The Dalles, Oregon, is the reference gage for the Columbia River Basin.

To meet Columbia River System FRM objectives, all storage projects in the system generally operate in a coordinated manner. Storage projects in the United States that are operated for U.S. FRM purposes include Congressionally authorized federal projects, as well as two non-federal projects.² In addition, three projects in Canada are available for U.S. FRM, pursuant to the Columbia River Treaty.³ For this consultation, the Action Agencies are only consulting on the effects of the operation and maintenance of the 14 federal CRS projects described in this Proposed Action.

Federal dams operate in accordance with their WCMs and other operational guidance manuals while the non-federal projects with system flood storage in the United States are operated in accordance with the Federal Energy Regulatory Commission (FERC) licenses issued to these project operators. FERC must

² Brownlee and Séliš Ksanka Qíispé [formerly known as Kerr] Dam.

³ Mica, Duncan, and Hugh Keenleyside dams in British Columbia.

consult with the Corps to assure the non-federal projects with flood storage are operated in accordance with Corps regulations, including the development and implementation of FRM operating criteria.

Through various authorities enacted by Congress, the Corps is responsible for FRM regulation of both federal and non-federal reservoirs in the United States with the objective of reducing flows to non-damaging levels as much as possible or regulating floods to the lowest possible levels. Through the previous ESA consultations with both NOAA Fisheries and USFWS, FRM requirements have been accounted for. System FRM operations are briefly described below, followed by dam-specific FRM operations.

2.3.1.1 System Flood Risk Management

Flood risk management is a year-round system operation; however, the categories of operation are generally binned by fall drafting operations (September–December) when reservoirs require lowering, or drafting, to meet FRM objectives, winter storage evacuation operations (January–April), and refill operations in the spring and summer (May–July) as described below.

FALL OPERATIONS: SEPTEMBER–DECEMBER

Generally, system FRM operations are minimal during the September-through-December period. Some storage projects have end-of-December target elevations that require drafting, the reservoir levels to achieve the specific FRM objectives that are unique to each dam and reservoir. Dworshak and Hungry Horse dams have fixed rule curves⁴ requiring end-of-December drafts for managing winter flood events; however, other operational purposes will generally bring the reservoir levels lower than the December FRM requirements. Grand Coulee (Lake Roosevelt)⁵ does not have a fall FRM requirement. At Albeni Falls Dam, the target date to be within six inches of the minimum control elevation (MCE) is November 15. This date is at the request of the Idaho Department of Fish and Game to protect kokanee spawning and incubation in Lake Pend Oreille. In the case of unusual hydrologic conditions, Albeni Falls Dam has the flexibility to be within six inches of the MCE by November 20. At Libby Dam, end-of-December FRM draft requirements are variable and set by the December 1 water supply forecast. John Day reservoir typically operates from 262.0 to 266.5 feet, with seasonal restrictions during the year, and for FRM as needed on the lower Columbia River, from 257 to 268 feet.

STORAGE EVACUATION OPERATIONS: JANUARY–APRIL

During the January-through-April period, the CRS storage projects operate to the storage reservation diagram (SRD) unique to each dam. The SRDs determine the maximum allowable elevation for each reservoir based on a given water supply forecast. Within the first 10 days of each month, from January through April, an official water supply forecast is prepared for each storage project and many locations throughout the Columbia River Basin, including The Dalles Dam. In very wet winters when there is abundant snowpack, the objective is to have appropriate storage space to accommodate the expected

⁴ A fixed rule curve means that the FRM requirement is the same for each year.

⁵ Reference to Grand Coulee regarding elevation requirements pertains to Lake Roosevelt

runoff and provide flows for ESA-listed and other fish. In dry winters that have less snowpack, the objective is to manage storage space to assure the reservoirs refill while maintaining reservoir space for unexpected spring rain events, like the flood events of 2012. Every year, the reservoirs are operated to maximize available water for fish during the migration season within FRM requirements.

In general, the storage projects are operated to meet FRM draft requirements to prepare for high spring flows and reduce the potential for flooding. The FRM operations end-date varies depending on the hydrologic characteristics of sub-basin and operational constraints, and as the forecasts are updated each month, the storage reservoirs will be drafted to their final FRM elevation by the end of March, April, or early May.

Periodically, the Action Agencies look for opportunities to shift system FRM requirements from Brownlee Reservoir (owned by Idaho Power) and Dworshak to Grand Coulee from January through April to provide more water for flow augmentation in the lower Snake River during spring migration. The shift allows operators to draft the Grand Coulee more deeply in the winter to keep the Brownlee and Dworshak reservoirs at higher levels. The reservoirs must meet their specific FRM elevation requirements by April 30. These shifts are implemented only after coordination with the Technical Management Team (TMT). Brownlee Reservoir is included in this shift, if requested by Idaho Power, to increase the probability for increased spring flows in the lower Snake River. The shift is based on end-of-month FRM elevations, as stated in the official water supply forecasts produced early each month during this time period. The Corps' and Reclamations' consideration of these FRM shifts will include an analysis of impacts on FRM, and the shift would not occur if FRM would be compromised.

REFILL OPERATIONS: MAY–JULY

During the May-through-July period, the CRS storage projects are operated to target reservoir refill limitations of the system and local FRM guidance. The projects on the Columbia River operate together to meet the initial controlled flow (ICF) at The Dalles Dam, while refilling reservoirs during the refill period (Figure 2-2).

The ICF is a calculated flow used in conjunction with the forecasts and available reservoir storage to determine when to start refill to assure 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%. 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 increase and refill, eventually reaching its targeted refill elevation when the risk of flooding has significantly decreased. The procedure and tools for these periods of regulation are presented in the WCMs for individual U.S. reservoirs.

For additional guidance for adjusting the controlled flow during the period of flood regulation refer to Chart 3 (Figure 2-3).

CRS reservoir operations generally target refill by June 30, but basin characteristics or other constraints may delay the peak elevation until sometime in July. For example, Lake Koocanusa, the reservoir behind Libby Dam in Montana, typically fills after June 30 because much of the snowmelt that feeds the lake occurs later in the season, and often local rain events require adequate storage space.

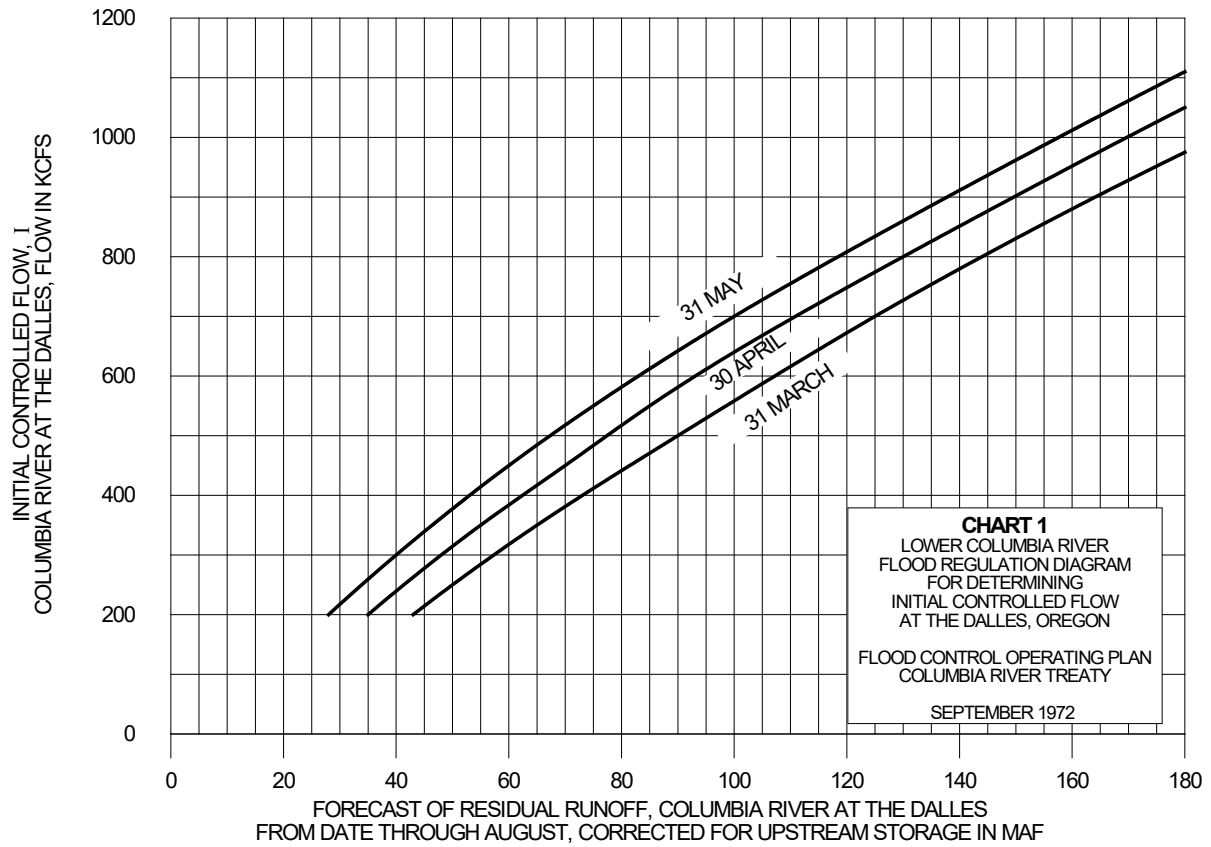


Figure 2-2. Lower Columbia River flood regulation diagram for determining initial controlled flow at The Dalles Dam, Oregon

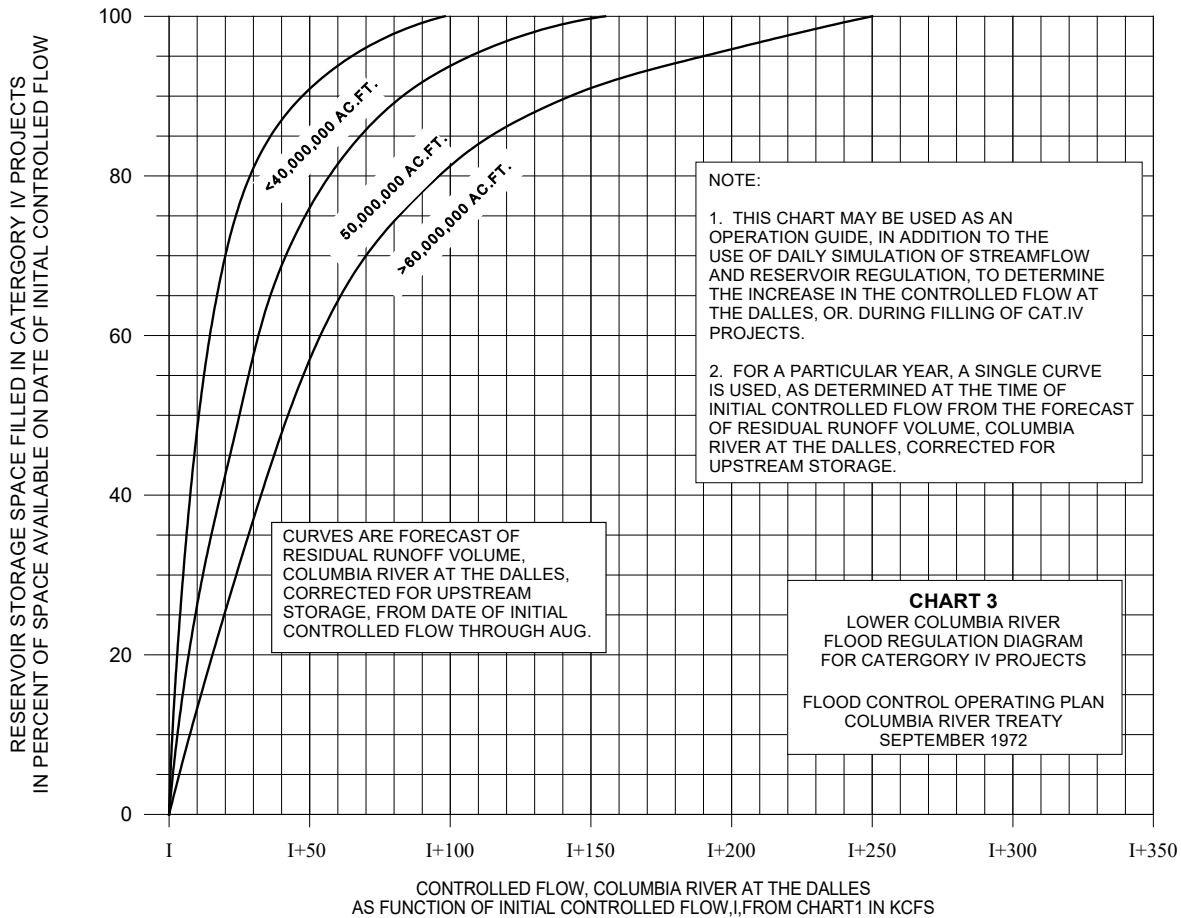


Figure 2-3. Lower Columbia River flood regulation diagram

2.3.1.2 Libby Dam Flood Risk Management

Libby Dam operations provide local and system FRM through regulation of spring flows in the Kootenai River valley, as measured at Bonners Ferry, Idaho, and in the mainstem Columbia River, as measured at The Dalles Dam, Oregon. Libby Dam is operated with updated VARQ (variable discharge)⁶ FRM procedures. Libby Dam operations for FRM are consistent with the requirements of the Columbia River Treaty and the International Joint Commission Order of 1938 on Kootenay Lake. The Corps’ Libby WCM is the main reference source for dam operations to meet water management requirements. The Libby

⁶ The VARQ FRM procedure was developed to improve the multi-purpose operation of Libby and Hungry Horse dams while not reducing the level of flood protection in the Columbia River. VARQ FRM reduces the contribution of reservoir space at Libby and Hungry Horse dams for system flood risk management that addresses spring runoff in the Columbia River in years when the potential for flooding is moderate. Correspondingly, the procedure was designed to provide higher outflows from the projects during the spring runoff than were made under the standard FRM operation. These outflows are more consistent with releases made to meet flow objectives for the ESA-listed Kootenai River white sturgeon and Columbia and SR salmon and steelhead.

WCM will be updated following the conclusion of consultation with NMFS and FWS and conclusion of the CRSO EIS process.

FALL OPERATIONS: OCTOBER–NOVEMBER

The October and November elevation targets are set to reach the December 31 FRM elevation by using the powerhouse capacity at Libby Dam. The reservoir is required to be below elevation 2,448 feet (0.5 million acre-feet [MAF] of space) by November 30.

STORAGE EVACUATION OPERATIONS: DECEMBER–MARCH

Libby Dam operations follow a variable end-of-December FRM rule curve based on the water supply forecast. In most years, the target elevation is 2,411 feet, but this target may be relaxed up to 2,426 feet when the water supply forecast is below normal (5.9 MAF). The project is operated during the December-through-March period (into April if the start of refill has not been declared) in accordance with the updated VARQ FRM storage reservoir diagram, as shown in Figure 2-4. The drawdown is based on the first of month April-to-August water supply forecast, which then sets the end-of-month draft or drawdown targets. The use of the SRD and the first-of-the-month forecast results in higher water supply estimates that correspond to deeper reservoir drafts and shallower reservoir drafts for years during which water supply is forecasted to be low.

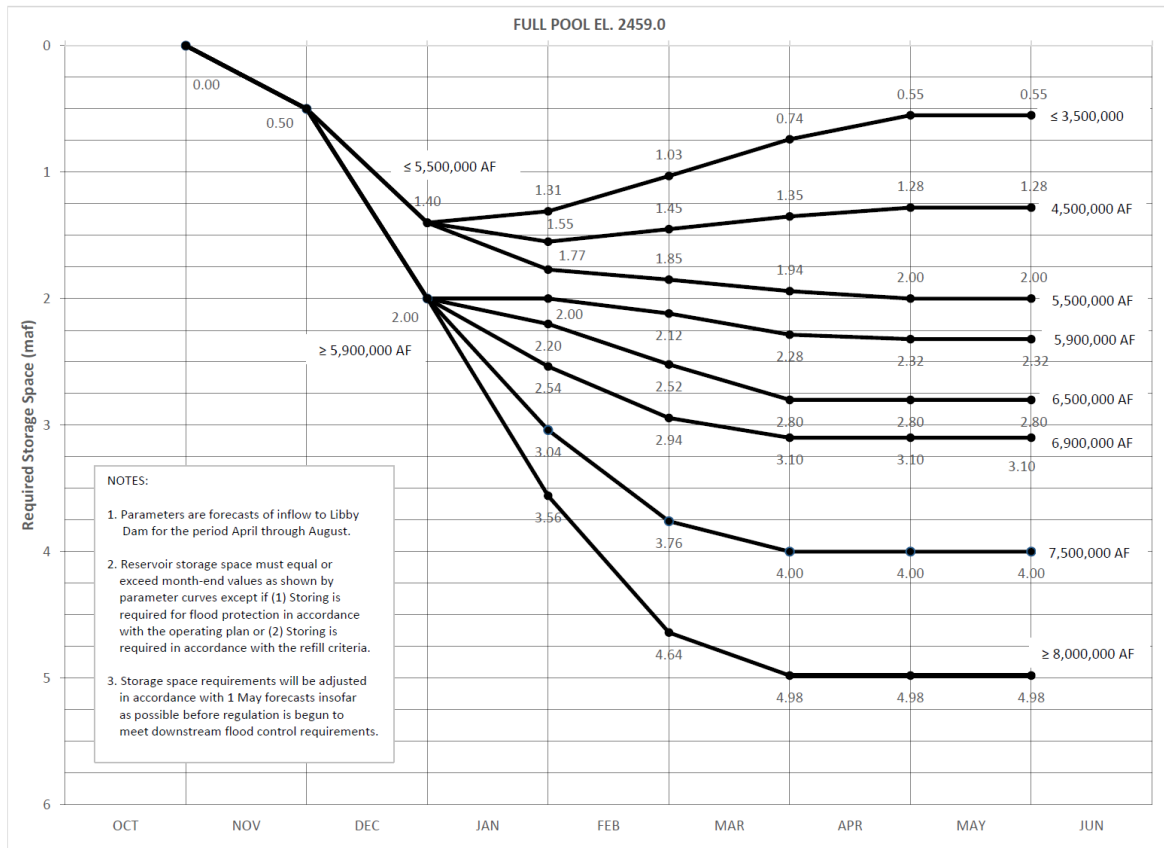


Figure 2-4. Libby Dam VARQ storage reservation diagram, October 2019

REFILL OPERATIONS: APRIL–JUNE

During the refill period (which can start as early as April and continue until early August), Libby Dam will release flow, at minimum, at or above the minimum required in accordance with by the updated VARQ FRM operating procedures at Libby Dam for refill. A modified operation has been proposed at Libby Dam to provide water managers with more flexibility to respond to local conditions in the upper basin. Refilling at Libby Dam will begin on May 1 for forecasts below 6.9 MAF and either approximately 10 days before the forecasted unregulated flow at The Dalles Dam is expected to exceed the ICF or on May 1, whichever is earlier, for forecasts at and above 6.9 MAF. Additionally, refill at Libby Dam may be initiated when the forebay level at Libby Dam is anticipated to fall below the Flood Control Refill Curve (FCRC⁷). Once refill begins, Libby Dam outflow will be no lower than the computed VARQ flow (or inflow, if that is lower than the VARQ flow), unless otherwise allowed by the updated VARQ operating procedures. During flood season, Corps reservoir regulators operate Libby Dam for system FRM and to minimize flood consequences by trying not to exceed, as much as possible, a river stage of 1,764 feet at Bonners Ferry, Idaho.

SUMMER OPERATIONS: JULY–SEPTEMBER

After the refill period, Libby Dam releases are managed to provide flows for the benefit of salmon and steelhead outmigration in the lower Columbia River and maintaining required minimum bull trout flows through the end of September by drafting to meet the September 30 targets. The end-of-September targets are determined based on the Corps Seattle District Libby Dam May Final Official Water Supply Forecast from April through August, and will be 5 to 20 feet from full, linearly interpolated from the criteria listed in Table 2-2.

Table 2-2. End-of-September elevation draft limits for summer flow augmentation at Libby Dam

Local Water Supply Forecast (percentile) ^a	Minimum	Less than or Equal to 15th Percentile	25th Percentile	75th Percentile	Greater than or Equal to 85th Percentile	Maximum
End-of-September elevation target (feet)	2,439	2,439	2,449	2,449	2,454	2,454

^a Based on the May final Corps Libby Dam water supply forecast from April to August. The 15th percentile, or 15% driest years, is currently approximately 4.66 MAF, the 85th percentile is currently approximately 7.33 MAF—both based on the current official 30-year period of 1981 to 2010. These values will be updated based on the next official 30-year period from 1991 to 2020 in early 2021.

The summer releases allow the project to refill to its maximum elevation generally during late July to early August (Figure 2-5). If the project is forecasted to fail to refill to the targeted end-of-September water level, Libby Dam will be operated to pass inflow or operated to maintain minimum flows through the summer months (Figures 2-6 and 2-7).

⁷ Flood Control Refill Curves are curves to help guide the refill of reservoirs and as much as possible ensure that flood control regulation does not adversely affect refill. These curves define the lower limit of reservoir drawdown that can be filled with a 95 percent assurance.

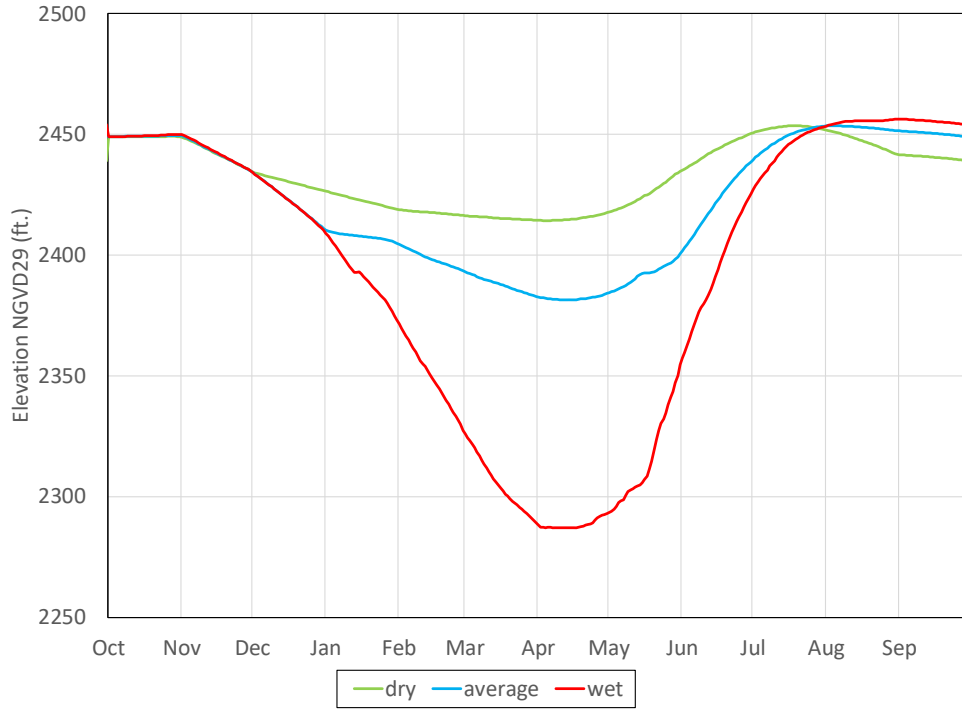


Figure 2-5. Modeled wet, average, and dry water year pool elevations at Libby Dam

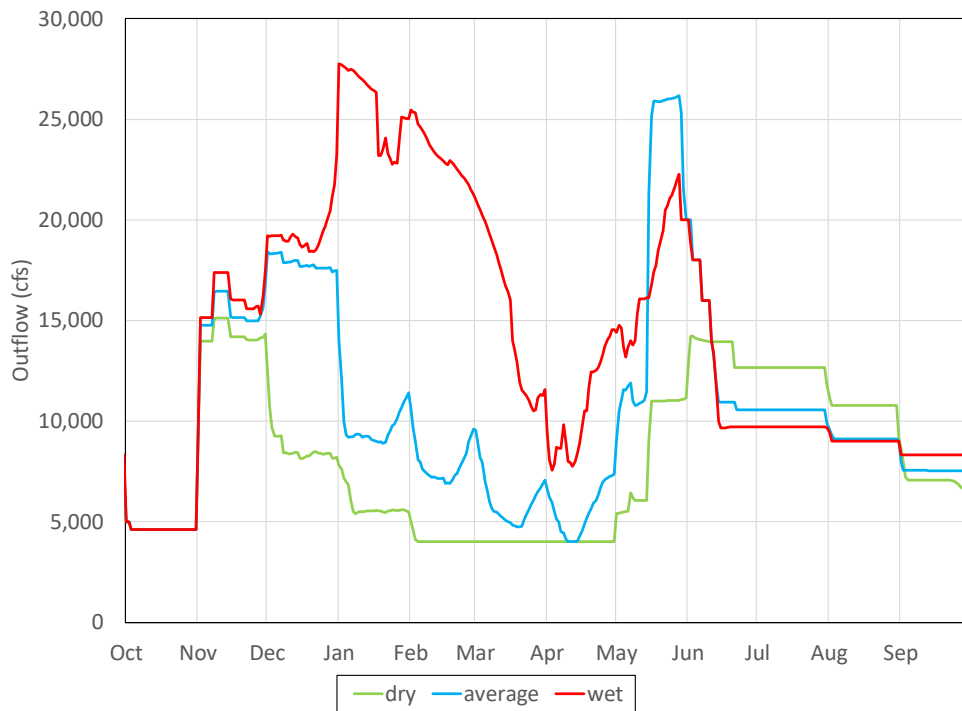


Figure 2-6. Modeled outflow at Libby Dam

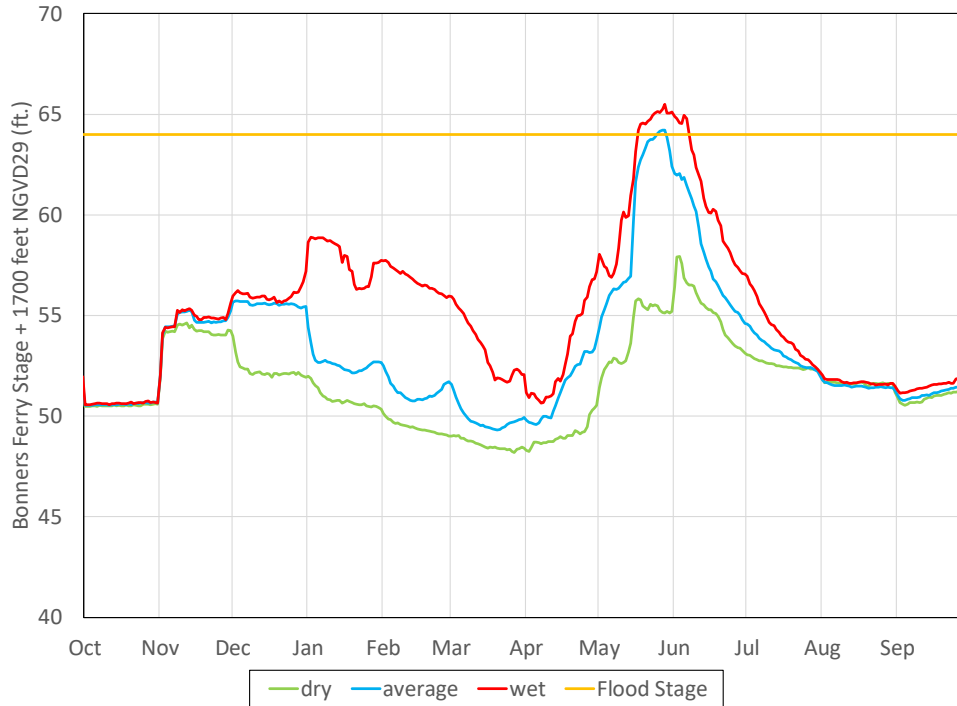


Figure 2-7. Modeled river stages at Bonners Ferry

In sum, Libby Dam will be operated for FRM as described above and in accordance with the Action Agencies' annual Water Management Plan (WMP), which includes specific provisions for fish and wildlife and the following actions:

- Follow updated VARQ FRM procedures. When not operating to minimum flows, the Corps will operate Libby Dam to achieve a 75 percent probability of reaching the elevation objective to provide spring flows (upper FRM rule curve on or about April 10; the exact date will be determined in season, based on the Corps Seattle District Libby Dam April through August forecast of water volume in the Kootenai River Basin of the CRS).
- Operate to provide tiered Kootenai River white sturgeon augmentation volumes to achieve habitat attributes for sturgeon spawning/recruitment during all or portions of in April, May, June, and July (as determined by WSF and sturgeon behavior), shaped by the FPIP team process in coordination with the Regional Forum including the TMT. (See Section 2.1 for information about the Regional Forum.) Following sturgeon pulse, operate to provide even or gradually declining flows during the summer months (avoid or minimize double peak operation). A double peak operation at Libby Dam is defined as an increase in discharge of greater than 2,000 cubic feet per second (cfs) while discharges are between 9,000 and 16,000 cfs, and an increase in discharge of greater than 5,000 cfs while discharge is 16,000 cfs or greater.
- Provide for summer flow augmentation; attempt to refill within 5 feet of full (full is 2,459 feet) in July or early August while also managing total dissolved gas and meeting FRM objectives.
- Provide summer flow augmentation to provide flow augmentation draft limits for anadromous fish in the Columbia River as determined by the May Libby water supply forecast. The Corps

attempts to draft consistent with the values provided in Table 2-2, and drafts range from 5 to 20 feet from full depending on water supply conditions.

- From May 15 through the end of the sturgeon flow augmentation operation and from September 1 through September 30, the minimum flow for bull trout habitat inundation will be 6,000 cfs (Hoffman et al. 2002). From the end of the sturgeon pulse through August 31, the minimum flow for bull trout will be 6,000 to 9,000 cfs, based on the final May water supply forecast.
- From October 1 through May 14, release a minimum of 4,000 cfs⁸ for resident fish.
- Limit spill to avoid exceeding the Montana State total dissolved gas (TDG) saturation standard of 110 percent, when practicable, and in a manner consistent with the Action Agencies' responsibilities for ESA-listed resident fish. For context, if scheduled spill tests are excluded, spill (for FRM purposes) has occurred three times since 2010.
- Limit outflow fluctuations by operating in accordance with the ramping rates described in Section 2.3.2 to avoid stranding bull trout.
- See Section 2.4.1 for a more detailed description of storage project operation for fish and wildlife at Libby Dam.

2.3.1.3 Hungry Horse Dam Flood Risk Management

Hungry Horse Dam operations provide local and system FRM through regulation of flows in the south fork for the local FRM control point, located downstream in the mainstem Flathead River at Columbia Falls, Montana, and for system FRM in the lower Columbia River. Hungry Horse Dam is operated consistent with its updated VARQ FRM procedures. The Corps-developed WCM for Hungry Horse Dam is used by Reclamation as guidance for dam operations to meet FRM needs.

FALL OPERATIONS: OCTOBER–DECEMBER

Hungry Horse Reservoir typically drafts throughout the fall to meet minimum flows at Columbia Falls on the mainstem Flathead River; by the end of December, the reservoir can be an additional 15 to 20 feet below the end-of-September elevation target (see Section 2.3.2 for additional information) due to minimum flow requirements. The reservoir is required to be below elevation 3,555 feet (0.10 MAF of space) from October 31 through November 30 and below elevation 3,549 feet (0.25 MAF of space) by December 31.

STORAGE EVACUATION OPERATIONS: JANUARY–APRIL

Reclamation generally drafts Hungry Horse Reservoir below the required FRM elevations to meet minimum flow requirements at Columbia Falls for resident ESA-listed fish. In water years when minimum flows do not draft the reservoir below the required FRM elevations, Hungry Horse Dam

⁸ 4,000 cfs is the normal minimum flow identified in the 1984 water control manual and was likely originally established for fishery purposes ("fishermen prefer stable flows in the range of 4,000 to 8,000 cfs"), though this is unclear.

operates in accordance with the VARQ FRM storage reservoir diagram (Figure 2-8). Hungry Horse Dam is operated for both local and system FRM, based on Reclamation’s May–September water supply forecast for Hungry Horse Dam.

On April 30, Hungry Horse Reservoir is typically at its lowest seasonal elevation to capture the high flows during spring runoff and to reduce the risk of downstream flooding.

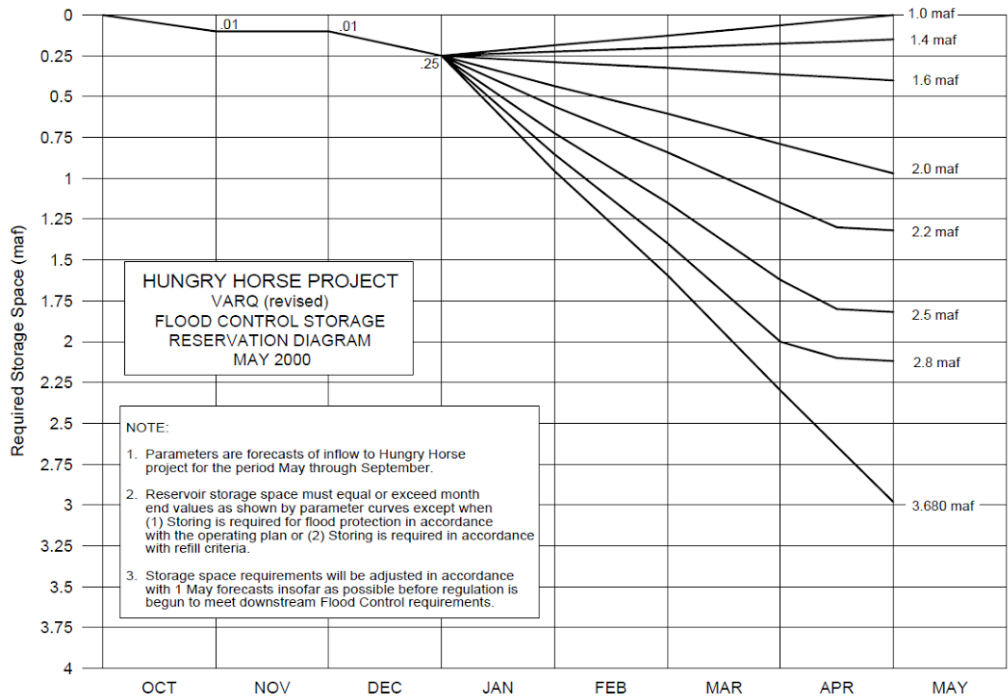


Figure 2-8. Hungry Horse Dam VARQ FRM storage reservation diagram

REFILL OPERATIONS: MAY–JUNE

Hungry Horse storage reservoir diagrams are designed for both local and system FRM. For the system, Reclamation coordinates with the Corps regarding when to begin refilling Hungry Horse Reservoir in the spring. During refilling, discharges from Hungry Horse are determined using inflow volume forecasts, streamflow forecasts, weather forecasts, and the VARQ operating procedures.

The Corps computes the ICF at The Dalles Dam and estimates the day that the controlled flow is expected to be reached. When unregulated flows at The Dalles Dam are equal to the ICF, refilling the reservoirs can begin. The refilling of Hungry Horse Reservoir can start 10 days before the date that the ICF is expected to be met.

As spring flows increase, Reclamation typically does not need to make releases to meet minimum flows at Columbia Falls, but releases either the VARQ discharge flow or the minimum flow requirement below the project on the South Fork Flathead River. As flows in the mainstem Flathead River increase, Reclamation must balance refill of Hungry Horse Reservoir while maintaining flows at Columbia Falls below the flood stage of 14 feet (approximately 51,000 cfs) when the elevation of Flathead Lake is

below the top foot (lower than elevation 2,892 feet), and below a stage of 13 feet (approximately 44,000 cfs) when the elevation of Flathead Lake is within 1 foot of full (at or above elevation 2,892 feet).

Reclamation typically tries to refill Hungry Horse Reservoir by approximately June 30. However, the timing and shape of the spring runoff may result in reservoir refill before or after the June 30 target date.

SUMMER OPERATIONS: JULY–SEPTEMBER

In wetter years, refill can be delayed until mid-July. After the refill period, Hungry Horse Dam releases are set to meet the September 30 elevation objectives. Reclamation attempts to draft Hungry Horse Reservoir by the end of September by 10 to 20 feet (elevations 3,550 to 3,540 feet) depending on the May local water supply forecast (for more information see Section 2.3.2.1, Table 2-8). These reservoir drafts are meant to support summer flows for juvenile salmon migration downstream of Chief Joseph Dam. In some dry years, Hungry Horse Dam will need to draft below the end-of-September objective to meet minimum flows at Columbia Falls. These operations are presented in Figure 2-9 and Figure 2-10.

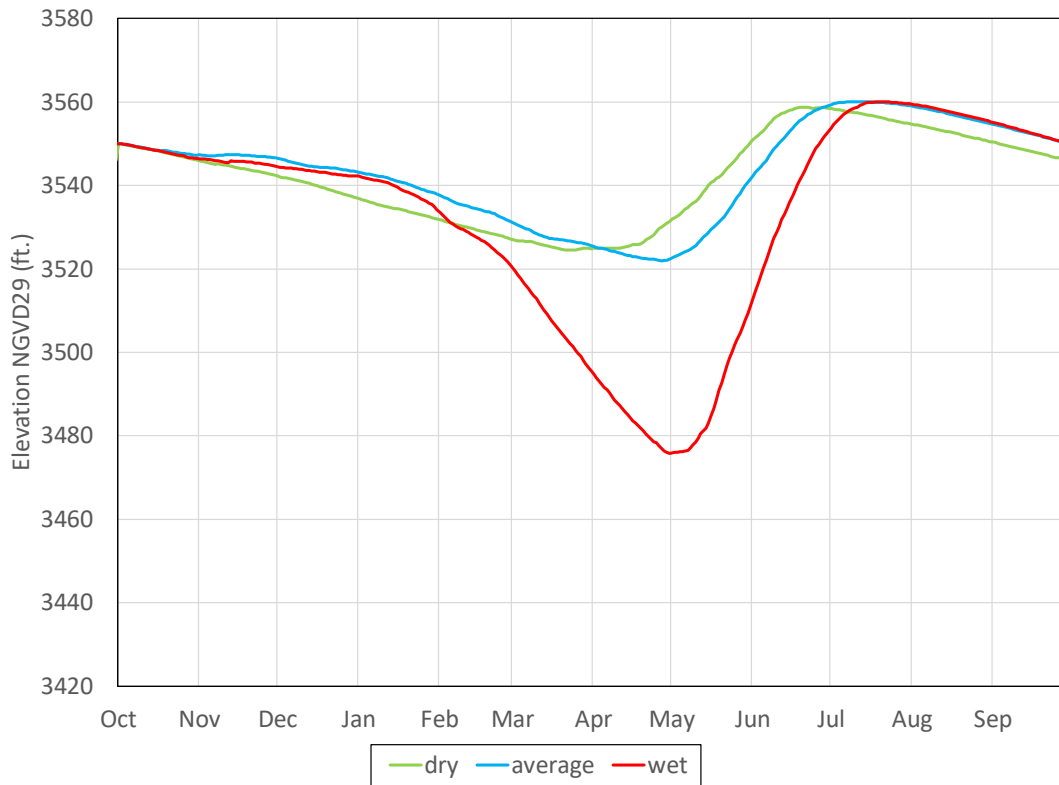


Figure 2-9. Modeled pool elevations at Hungry Horse Dam

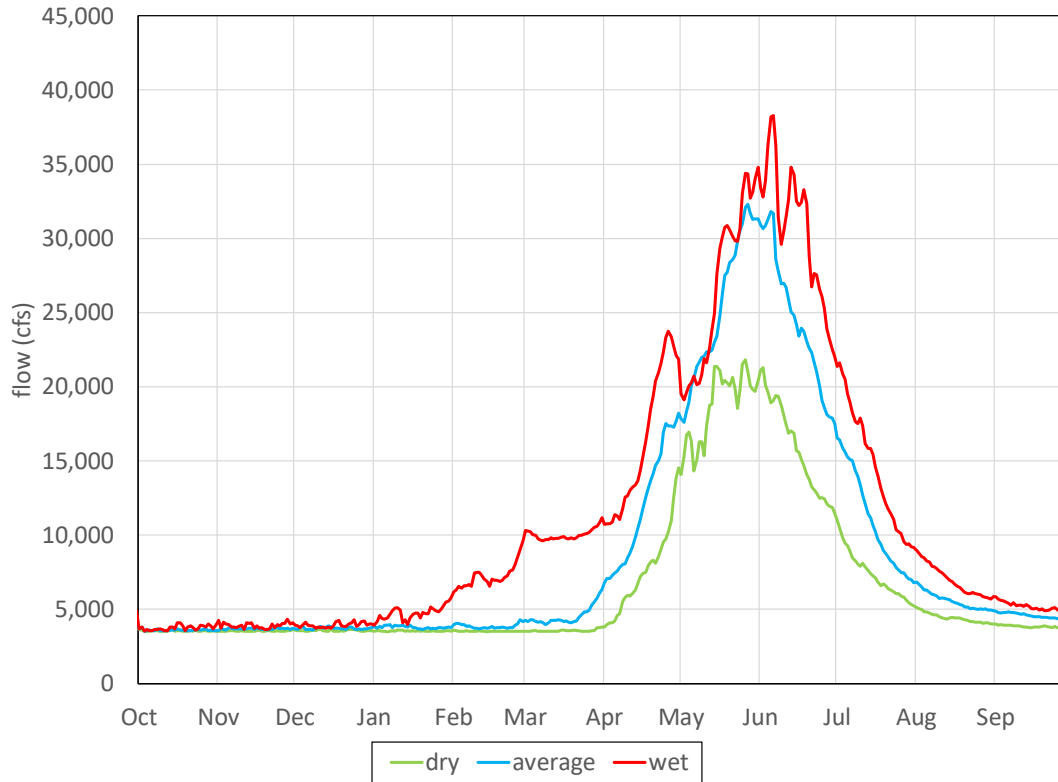


Figure 2-10. Modeled Flow at Columbia Falls

In sum, Hungry Horse Dam will be operated in accordance with the annual WMP, which includes specific provisions for fish and wildlife and the following actions:

- Follow VARQ FRM procedures. VARQ FRM procedures are designed to enable more flexible multipurpose operations that allow higher spring releases for ESA-listed migrating salmon and steelhead while maintaining current FRM protection levels and improving the ability to refill the reservoirs. When not operating to minimum flows, Reclamation will operate Hungry Horse Dam to achieve a 75 percent probability of reaching the April 10 objective to provide spring flows.
- Refill by about June 30 each year (exact date to be determined during in-season management).
- Provide summer flow augmentation; after refill the project is operated to end-of-September draft objectives to provide increased summer flows for anadromous fish in the Columbia River, as determined by Reclamation's local Hungry Horse basin water supply forecast (Table 2-8). In some dry years, the project will continue to draft below the draft objectives to meet the minimum flow requirements intended to benefit bull trout.
- Provide even or gradually declining flows during summer months (avoid or minimize double peak operation).
- Maintain minimum flows all year for listed bull trout, with a sliding scale based on the forecast. Operate to meet minimum flows of 3,200–3,500 cfs at Columbia Falls on the mainstem Flathead River and 400–900 cfs in the South Fork Flathead River (Table 2-6).

- Limit outflow fluctuations by operating in accordance with ramping rates to avoid stranding bull trout (Table 2-7).

2.3.1.4 Albeni Falls Dam Flood Risk Management

Albeni Falls Dam is a storage project with fixed FRM criteria that is not dependent on water supply forecasts. Flood damage reduction benefits of the Albeni Falls project are realized for Lake Pend Oreille and the portion of the Pend Oreille River impounded by Albeni Falls Dam by lowering the maximum stage of Lake Pend Oreille for peak floods to between 80,000 cfs and 220,000 cfs. Figure 2-11 shows the annual operating limits for Lake Pend Oreille within the solid black lines.

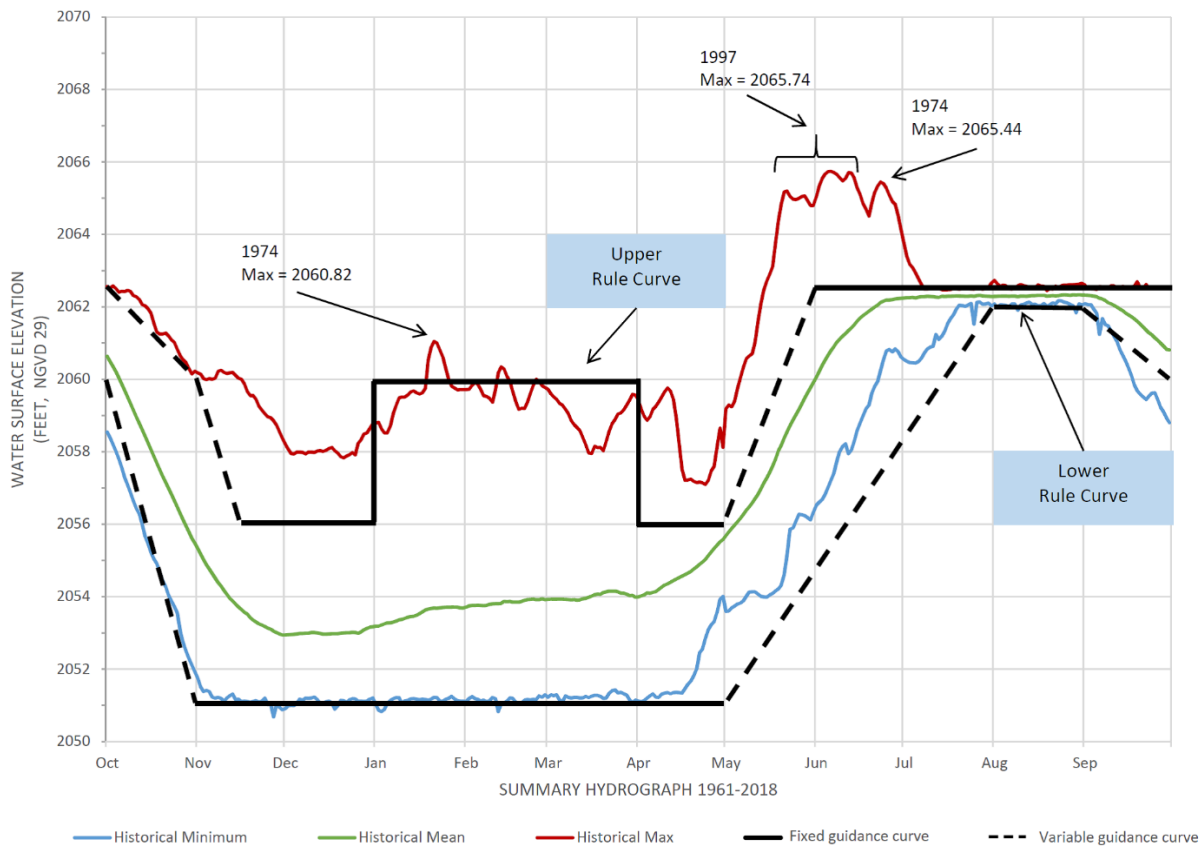


Figure 2-11. Summary hydrograph for Lake Pend Oreille

FALL OPERATIONS: OCTOBER–NOVEMBER

Drafting at Lake Pend Oreille begins in mid-September, and Lake Pend Oreille is drafted down to within 0.5 feet of the winter MCE of 2,051 feet by mid-November. During the month of October and through the first week of November, the Corps drafts the project, targeting to be within six inches of the MCE, typically 2,051 feet, by November 15 in response to the Idaho Fish and Game (IDFG) request to provide spawning grounds for early spawning kokanee and no later than November 20, depending on hydrologic conditions.

WINTER HOLDING PERIOD AND POWER OPERATIONS: DECEMBER–MARCH

The Corps holds Lake Pend Oreille within six inches of the MCE after mid-November until IDFG declares that kokanee spawning is over, or by a certain date (i.e., December 31), whichever occurs first.⁹ The Corps coordinates with IDFG to determine the best time that water can be stored in Lake Pend Oreille for flexible winter power operations without affecting kokanee redds. After kokanee spawning has stopped, the Corps can operate the lake to 1 foot above the MCE. The 1-foot operating band can only be exceeded for FRM or power requests. Flexible winter power operations may occur after IDFG has declared the end of kokanee spawning and remains in effect through the end of March. During this period, the elevation of Lake Pend Oreille can fluctuate between 2,051 and 2,056 feet (maximum storage allowed for power purposes) at Bonneville’s request and with Corps approval, in consideration of downstream power system needs. These power storage requests would be expected to occur every year or every few years. The lake can be operated in the winter up to an elevation of 2,060 feet to meet short term (i.e., 2 to 14 days) local or system flood risk management needs. For a system flood risk request, short term storage of water at Albeni Falls would decrease the stage on the mainstem Columbia River. This type of operation is infrequent (one time in ten years). The last time it occurred was in March 2017.

REFILL OPERATIONS: APRIL–JUNE

The Corps monitors snowpack status leading up to and during the spring flood season from April to mid-July. Runoff normally increases during April and May and the peak discharge into the lake occurs during May or June. If flood runoff is anticipated, the spillway gates may be raised above the water to establish free flow conditions. Modeled outflow for Albeni Falls Dam is shown in Figure 2-12. The Corps monitors snowpack and weather forecasts to determine the best timing for refilling the reservoir to the summer operating range of 2,062.0 to 2,062.5 feet.

SUMMER OPERATIONS: JULY–SEPTEMBER

During the summer, Albeni Falls Dam is operated to pass water through and maintain a pool elevation of between 2,062 and 2,062.5 feet (the summer operating pool) (Figure 2-13). The summer operating pool is often held through Labor Day, after which the lake elevation operating band increases to 2,060 to 2,062.5 feet through the month of September. Lake levels during the month of September are based on in-season recreation, biological, and power generation needs for the Columbia River mainstem.

⁹ An exception applies when hydrologic conditions preclude the Corps from maintaining this elevation.

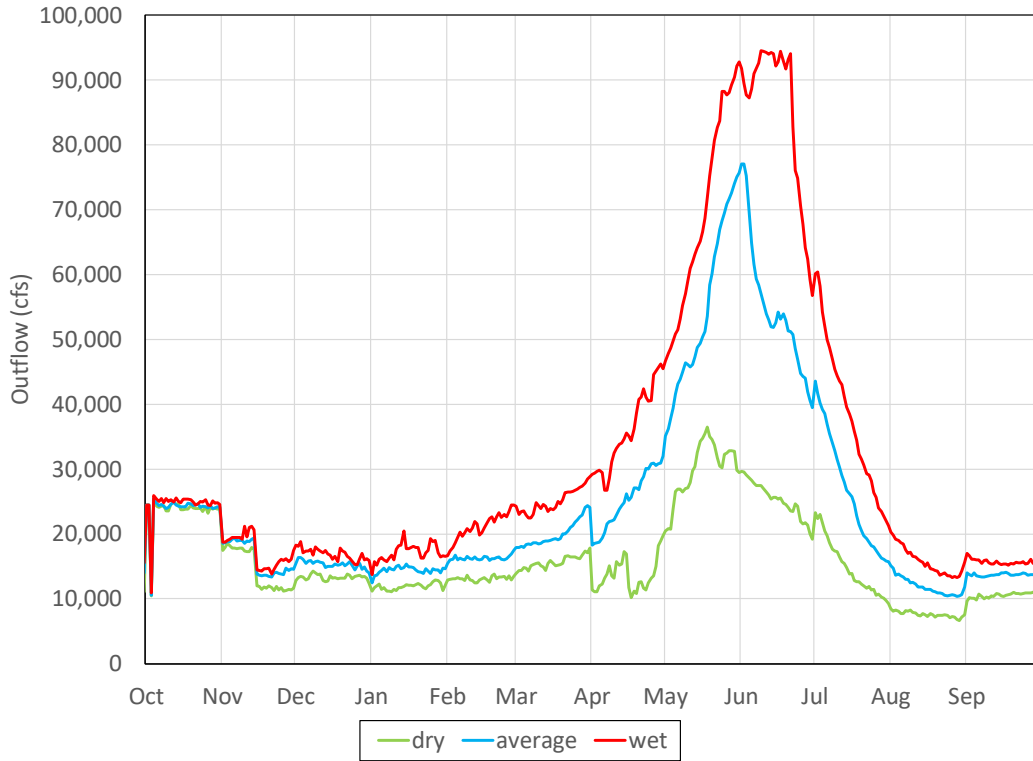


Figure 2-12. Modeled outflow at Albeni Falls Dam

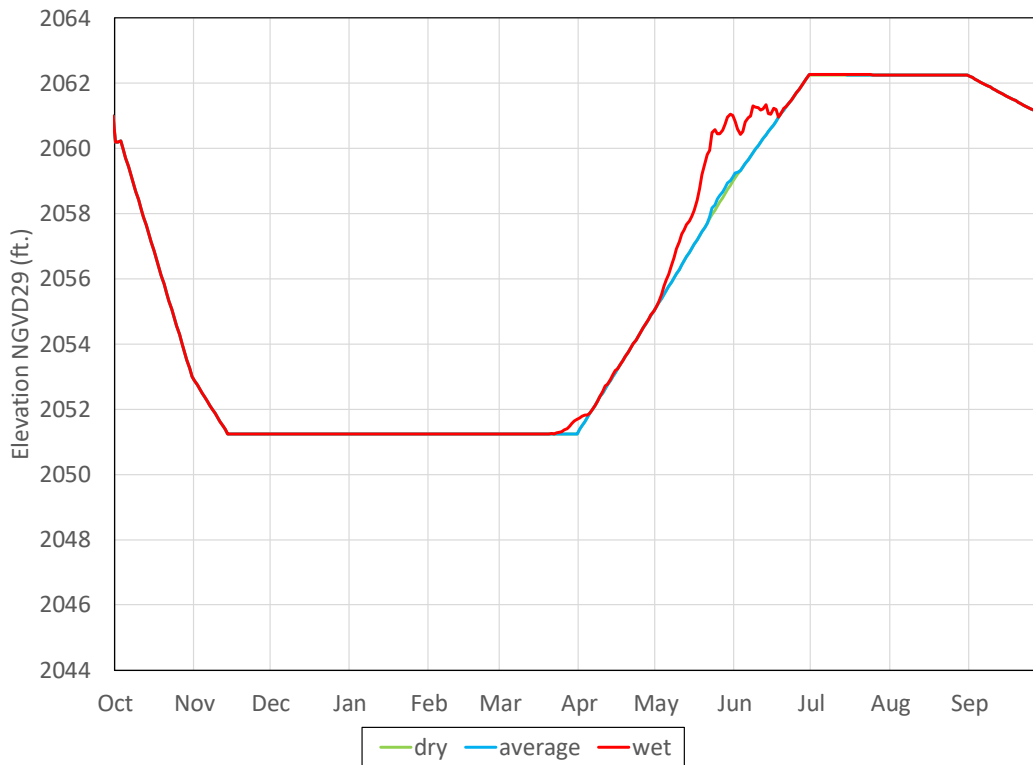


Figure 2-13. Modeled pool elevations at Albeni Falls Dam

In sum, Albeni Falls Dam will be operated for FRM as described above and in accordance with its WCM and the annual WMP, including operations for fish and wildlife, and will include the following actions:

- Operate in accordance with FRM criteria.
- Operate to provide Lake Pend Oreille shoreline spawning conditions for kokanee. This will generally include an MCE of 2,051 feet from December 1 to March 31.
- Maintain current lake and downstream ramping rates, as specified in the WCM.

2.3.1.5 Grand Coulee Dam Flood Risk Management

Grand Coulee Dam is operated on accordance with FRM criteria to provide FRM through regulation of flows for the Columbia River at The Dalles Dam.

FALL OPERATIONS: SEPTEMBER–DECEMBER

Grand Coulee Dam does not have an end-of-December FRM draft requirement; however, operations for other purposes, including power generation and water releases to help benefit chum salmon spawning and rearing areas in the mainstem Columbia River, typically draw down Lake Roosevelt below full pool by the end of December.

STORAGE EVACUATION: JANUARY–APRIL

Grand Coulee Dam is operated from January through April in accordance with FRM requirements, based on the April–August volume water supply forecast for The Dalles Dam. The Corps has established the Grand Coulee Dam storage reservoir diagram (Figure 2-14), which includes space requirements at Lake Roosevelt that are determined from The Dalles Dam runoff water supply forecast minus system storage space (other than at Lake Roosevelt) available upstream of The Dalles Dam. The Proposed Action changes the way that Lake Roosevelt is drawn down to reach flood space elevations in winter and spring at Grand Coulee Dam by reducing the planned draft rate to 0.8 feet per day. Under the proposed operation, the reservoir drawdown would begin earlier under some water supply conditions, and the reservoir elevations would be lowered more slowly to reduce the risk of landslides along the shoreline. Ultimately, the deepest lake elevation targets for system FRM are not changed by this measure, but the timing and rate for reaching the lower reservoir elevations would change.

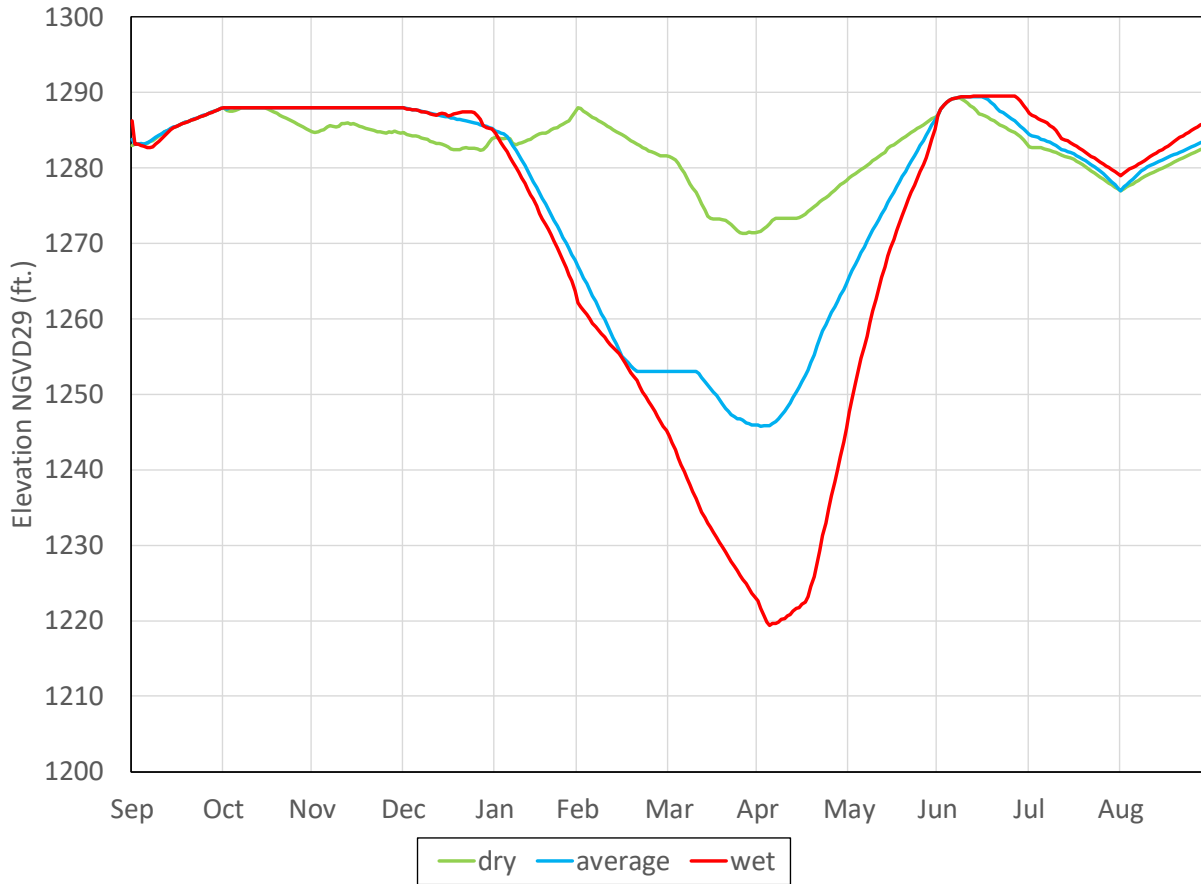


Figure 2-14. Modeled pool elevations at Grand Coulee Dam

Update System FRM Calculation at Grand Coulee Dam

Updating the FRM calculation at Grand Coulee Dam would change the end-of-month target flood space elevation of Lake Roosevelt at Grand Coulee Dam based on whether the storage reservoirs upstream of Grand Coulee had drafted to reach their required flood space elevations at the end of the months of January, February, March, and April (Figure 2-15). If one or more upstream storage reservoirs were unable to draft down to their required flood space elevations at the end of each of those months, Lake Roosevelt would be used to provide additional flood storage space for the CRS. This is a change from past operations to allow the Grand Coulee project to respond to changing conditions in the upstream storage reservoirs. There would be no change in the current level of FRM, but rather, a shift in where flood space is held.

Planned Draft Rate at Grand Coulee Dam

Changing the draft rate at Grand Coulee Dam would change the way that Lake Roosevelt is drawn down to reach flood space elevations in winter and spring by reducing the planned draft rate to 0.8 feet per day. Under the proposed operation, the reservoir drawdown would begin earlier under some water conditions, and the reservoir elevations would be lowered more slowly to reduce the risk of landslides along the shoreline. Ultimately, the deepest lake elevation targets for system FRM would not be

changed by this measure, but the timing and rate for reaching those lower reservoir elevations would change.

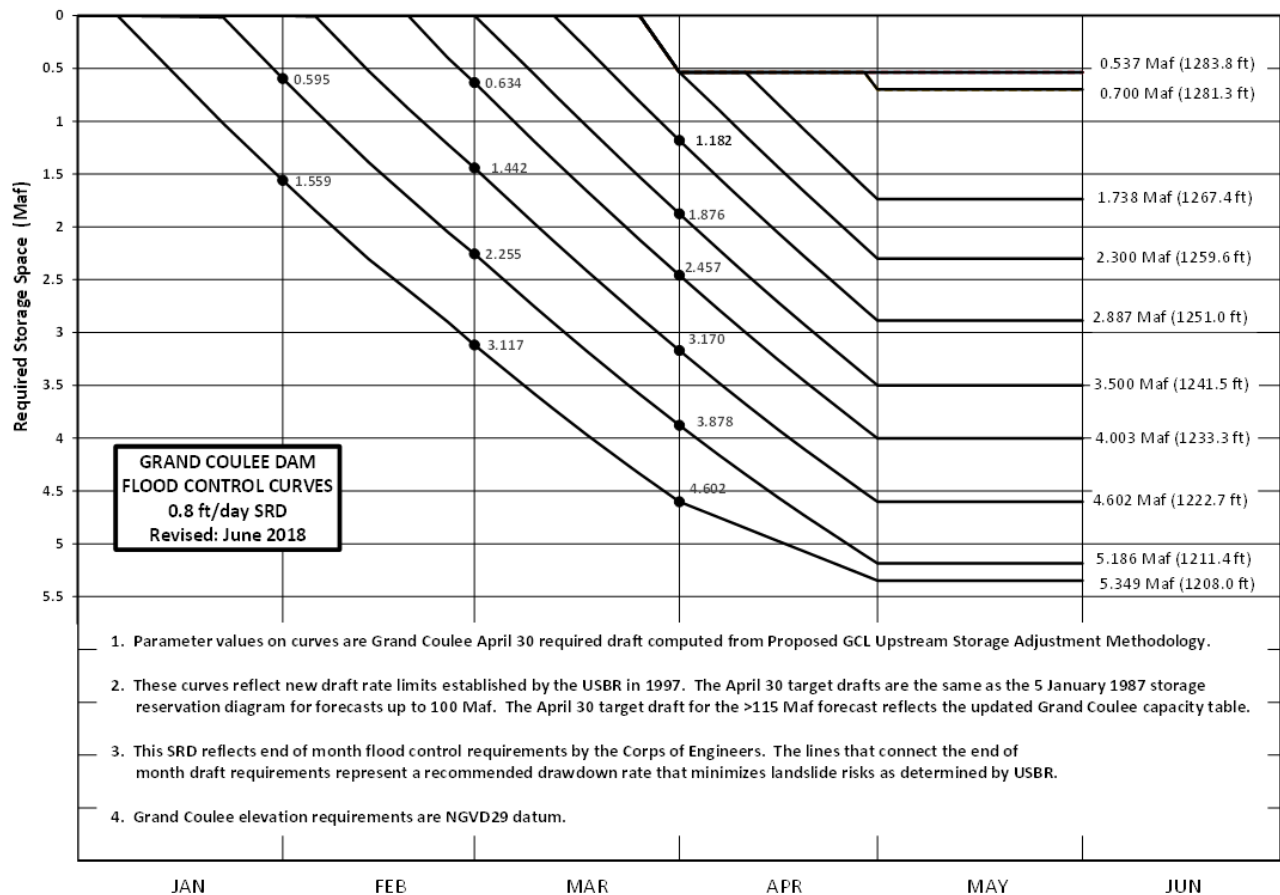


Figure 2-15. Flood risk management curves for Grand Coulee Dam, 2018

REFILL OPERATIONS: MAY–JUNE

To establish reservoir refill operations, the Corps computes the ICF at The Dalles Dam and estimates the day that controlled flow is expected to be reached. When unregulated flows at The Dalles Dam are equal to the ICF, refilling of the reservoirs can commence. Refilling at Lake Roosevelt can start 2 days prior (corresponding to the water travel time from Grand Coulee Dam to The Dalles Dam) to the date that the ICF is expected to be met (Figure 2-16).

SUMMER OPERATIONS: JULY–AUGUST

Reclamation typically targets refilling after the Fourth of July holiday, but in wetter water years, refilling can be delayed until mid-July to manage flows at The Dalles Dam. The refill elevation objective is adjusted to reduce impacts on spring flows consistent with the Lake Roosevelt Incremental Storage Release Project (LRISRP) and to reduce impacts from future water supply development (Appendix A). After the refill period, Grand Coulee Dam is operated to a variable August 31 draft objective of 1,278 to

1,280 feet based on the water supply forecast. If the July final April through August forecast for The Dalles Dam is equal to or greater than the 30-year average (the current 30-year average for the period of 1981 to 2010 is 87.5 MAF; the 30-year average will be updated in 2021 to correspond to the current 30-year period of 1991 to 2020) then Lake Roosevelt’s draft objective will be 1,280 feet. If the forecast is less than 30-year average, the draft objective will be 1,278 feet. To implement the LRISRP, the August 31 draft objective will be adjusted an additional amount, up to 1 foot in non-drought years and 1.8 feet in drought years

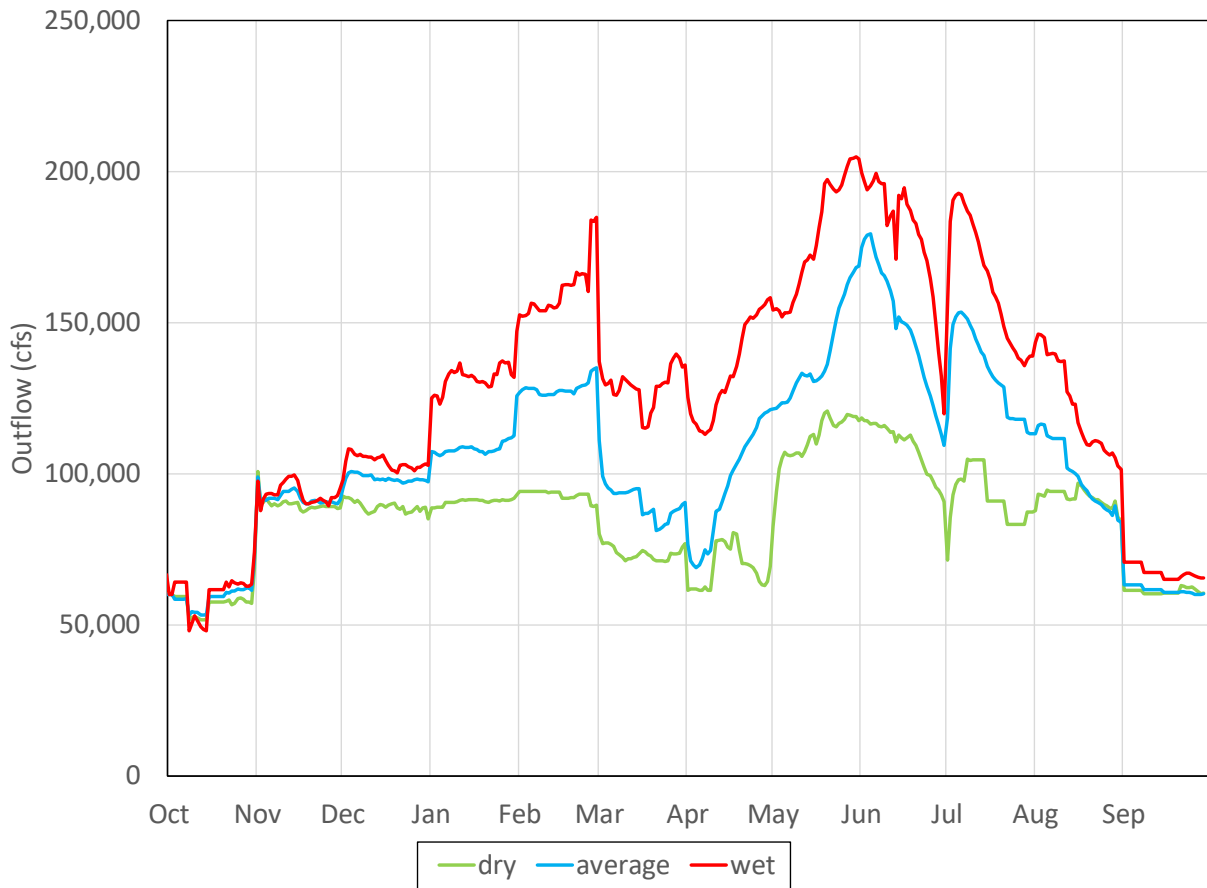


Figure 2-16. Modeled outflow at Grand Coulee Dam

In sum, Grand Coulee Dam will be operated for FRM as described above and in accordance with the annual WMP developed by the TMT, including operations for fish and wildlife, which will include the following actions (these operations are discussed in more detail in Section 2.3.2, Operations for Conservation of Fish and Wildlife):

- If possible, shift system FRM space temporarily from Dworshak and Brownlee to Grand Coulee to provide more water for spring flows in the Snake River during the spring migration. These shifts may be implemented after coordination with TMT to discuss trade-offs and impacts. The reservoirs must be back to their specific FRM requirements by April 30.

- Operate to achieve an 85 percent probability of reaching the April 10 elevation objective to help support flows during the spring salmon migration. This operation balances power operations with achieving spring elevation objectives.
- Refill after the Fourth of July holiday each year (exact date to be determined during in-season management). The refill maximum elevation is adjusted based on the LRISRP spring flow objectives and to reduce impacts of spring water supply deliveries (Appendices A and C).
- Draft to support salmon flow objectives during July and August with a variable draft objective of 1,278 to 1,280 feet by August 31 based on the July Final April through August forecast for The Dalles Dam.
- Use the LRISRP draft of up to an additional 1 to 1.8 feet by the end of August based on water supply forecast to enhance stream flows to benefit fish, and for water supply purposes.
- Reduce pumping into Banks Lake and allow Banks Lake to operate up to 5 feet from full pool (elevation 1,565 feet) during August to support salmon flow objectives.
- Operate to support tailwater elevations below Bonneville Dam from November through early April to support chum spawning and incubation when necessary and possible.
- Operate to support Priest Rapids fall Chinook salmon seasonal flow objectives.

2.3.1.6 Dworshak Dam Flood Risk Management

Dworshak Dam operations provide local and system FRM through regulation of winter and spring flows in the Clearwater River, lower Snake River, and lower Columbia River. Dworshak Dam is operated consistent with the Corps' Dworshak Dam WCM. This operation includes following operational rule curves and storage reservoir diagrams for both local and system FRM based on the runoff volume forecast.

Dworshak Dam is operated to meet minimum releases, which are performed during the fall operation period, and the reservoir elevation is maintained below the 1,558 feet end-of-December FRM target. The reservoir is required to be below the elevation of 1,558 feet (0.7 MAF of space) by December 15.

STORAGE EVACUATION PERIOD: JANUARY–APRIL

Dworshak Dam is operated for both local and system FRM, based on the April–July water supply forecast for Dworshak Dam, and operates in accordance with the FRM storage reservoir diagram (Figure 2-17). At the beginning of January, Dworshak is at or below the elevation of 1,558 feet, which provides a minimum 700,000 acre-feet of available storage. This represents the minimum end-of-December FRM space.

Releases from Dworshak are regulated so as not to exceed 25,000 cfs immediately below the dam in the North Fork Clearwater River or 115,000 cfs at Spalding, Idaho, whichever is most restrictive. As needed for system FRM, Dworshak Dam releases can be reduced to a minimum of 1,600 cfs to maintain the Columbia River at Vancouver, Washington, below flood stage (16 feet), if other project operating requirements are met.

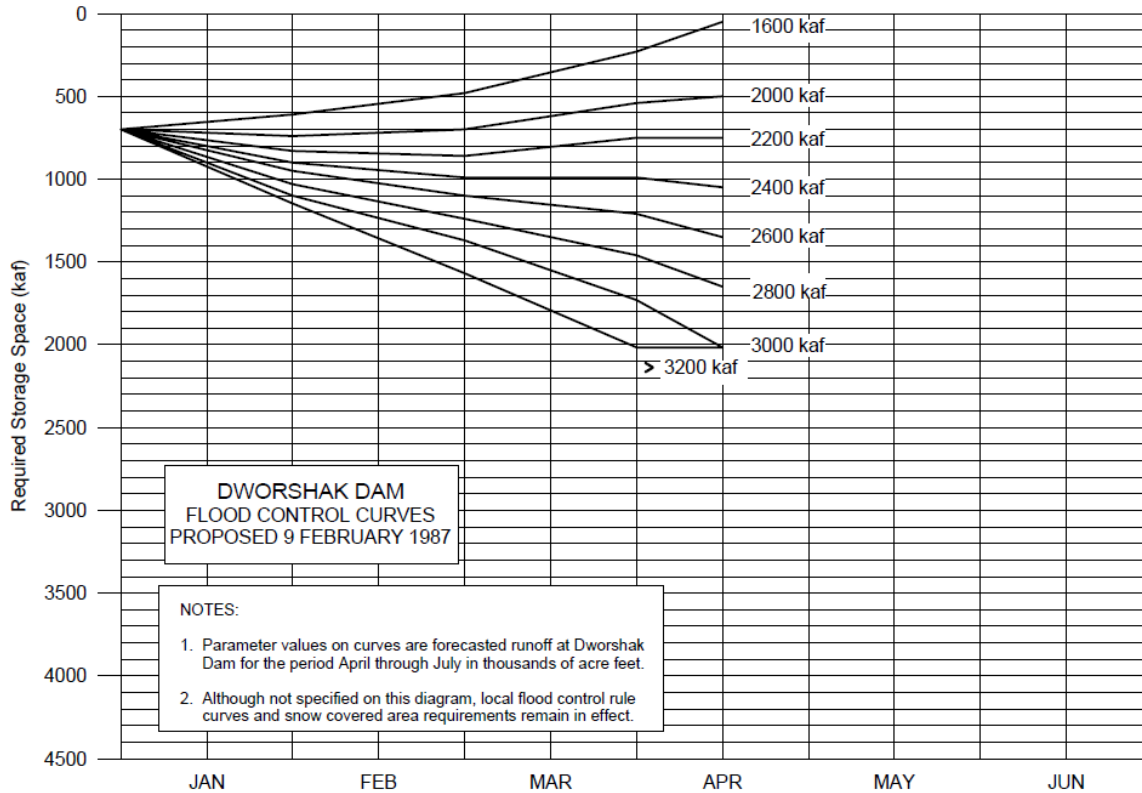


Figure 2-17. System flood risk management curves for Dworshak Dam

SPRING OPERATIONS: MAY–JUNE

When the system storage reservoir diagram intersects the FCRC, normally during the month of April, Dworshak Dam begins refilling. The FCRC uses an April–July runoff volume forecast and an estimated reservoir release to determine refill target elevations. Efforts are made to fill Dworshak Reservoir to an elevation of 1,600 feet by the end of June, or earlier (if possible), in accordance with the FCRC. Similar to the winter flood requirements described in the section above, spring floods are regulated to meet the same requirements for peak project outflows and flows at Spalding and Vancouver (Figure 2-18).

SUMMER OPERATIONS: JULY–SEPTEMBER

Once the reservoir is refilled, Dworshak Dam is operated in the summer for the gradual evacuation of water through a combination of temperature objectives to maintain Lower Granite Dam tailwater temperatures below 68°F and to reach an elevation of no lower than 1,535 feet by August 31 and an elevation of 1,520 feet by September 30 (Figure 2-19).

In sum, Dworshak Dam will be operated in accordance with the annual WMP, including operations for fish and wildlife, which will include the following actions:

- Operate in accordance with standard FRM criteria; shift system FRM to Grand Coulee Dam when possible, unless modified by procedures under dry-water-year operations. The shift in system

FRM space will end by April 30th, such that each project storage will satisfy their respective FRM space requirements.

- When not operating to minimum flows, operate to reach the upper FRM rule curve on or about April 10 elevation objective (the exact date to be determined during in-season management), to increase flows for spring flow management.
- At Dworshak Dam, calculate a VDL in season to increase power generation from January to March, while protecting the ability to refill with 95% confidence based on the March 31 FRM upper rule curve.
- Provide minimum and augmentation flows while not exceeding the state of Idaho TDG water quality standard of 110 percent saturation.
- Refill by about June 30 or earlier in dry years (exact date to be determined during in-season management).
- Draft no lower than an elevation of 1,535 feet by the end of August and to an elevation of 1,520 feet (80 feet from full) by the end of September, unless modified per the agreement between the United States and the Nez Perce Tribe for water use in the Dworshak Reservoir.
- Regulate outflow temperatures to attempt to maintain water temperatures in the Lower Granite Dam tailwater at or below 68°F, typically from July 1 through the end of September.

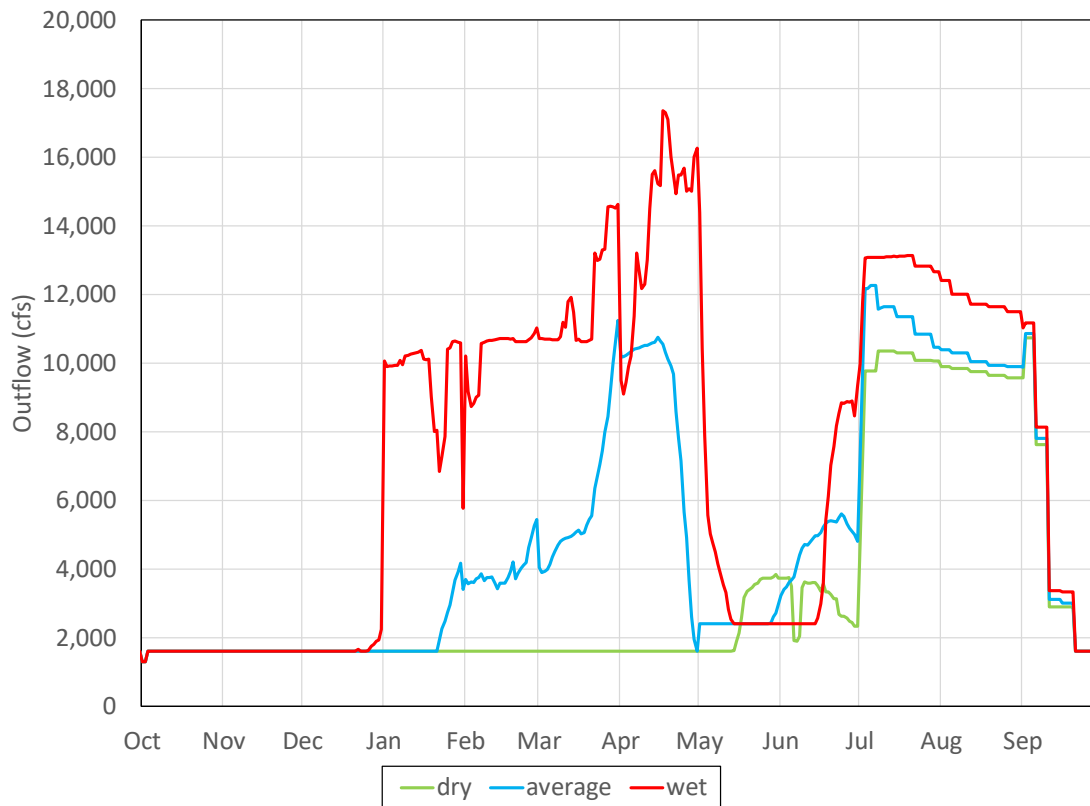


Figure 2-18. Modeled outflow at Dworshak Dam

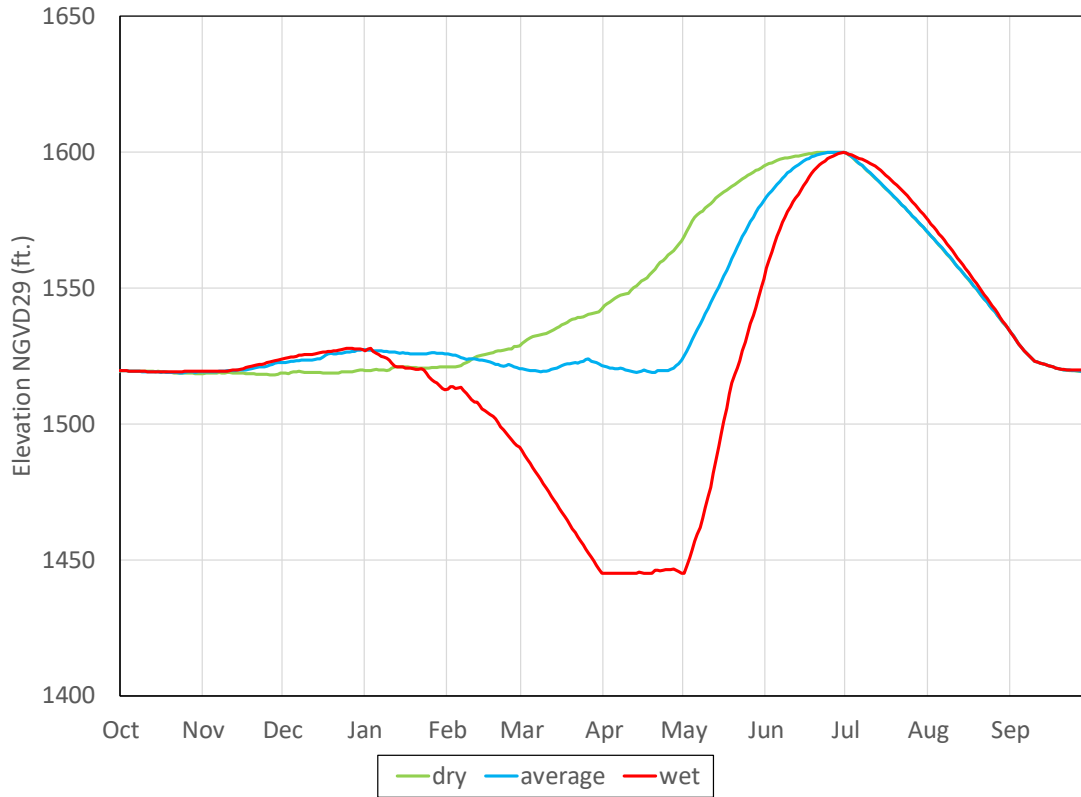


Figure 2-19. Modeled pool elevation at Dworshak Dam

2.3.1.7 John Day Dam Operations

While routinely operated as run-of-river, the project has approximately 0.5 MAF of flood storage between the minimum elevation of 257.0 feet and the maximum elevation of 268.0 feet. The reservoir storage is primarily designed to be used during winter and spring flooding to reduce flood stage near Vancouver and Portland but can also be used for similar purposes during peak spring freshet flows. During the winter period, FRM evacuation requirements are tied to the forecasted stage at Vancouver, Washington.

John Day reservoir operations for fish conservation and other purposes are summarized below (2.3.2.6) and in Table 2-13.

2.3.2 Operations for Conservation of Fish and Wildlife

Along with other authorized purposes, the Action Agencies coordinate CRS management to reduce adverse effects on ESA-listed and non-listed species in storage reservoirs and rivers downstream. This section covers anadromous and resident ESA-listed fish species and other species, such as non-listed salmonids, burbot, and lamprey. This section has three operation subsections for fish and wildlife: storage project operations, run-of-river project operations, system-wide operations, adaptive management, and in-season adjustments to system operations.

2.3.2.1 Storage Project Operations for Fish and Wildlife Conservation

The Action Agencies operate CRS storage projects to provide flows for ESA-listed fish, an important component of multipurpose water management in the Columbia River System. Columbia River flows are primarily driven by snowmelt; more than 60 percent of the annual runoff occurs between April and June. Natural flows drop significantly by late July and into August. Through coordination in the Regional Forum process (see Section 2.1), CRS project operations are designed to more effectively benefit the listed species and fulfill multiple other authorized project purposes. Figure 2-20 provides a high-level summary of the operational constraints (fish operations, FRM, power operation, etc.) and actions throughout the year that provide improved conditions for fish.

The Action Agencies use a variety of information to meet CRS management needs. Since available storage—water that can be managed—is limited relative to total annual runoff in the Columbia River Basin, one purpose of the storage projects is to reduce peak flood flows for FRM. This also allows projects to store water for use later (e.g., power, flow augmentation). Flow objectives have been identified for planning and implementing annual, seasonal, and shorter time-step operations to best meet the biological needs of ESA-listed fish within the context of FRM and other management objectives and project purposes.

The limited amount of water available for flow, augmentation of flow, and flow objectives leads to trade-offs among fish operation objectives. That is, improving flows for one evolutionarily significant unit (ESU) could reduce the water available for another. For example, flow protection levels for ESA-listed chum salmon below Bonneville Dam and non-listed fall Chinook salmon below Bonneville Dam and in the Hanford Reach are set in November and December, before the availability of reliable water supply forecasts. Significant volumes of water released from storage may be required to maintain flows and redd protection levels through the date of emergence, affecting the ability to achieve spring refill objectives designed to aid migrating juvenile salmon during April through June. See Sections 2.3.2.1–2.3.2.2 for additional operations associated with such trade-offs.

CRS Biological Assessment

Project	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Libby	Variable Discharge (VARQ) Flood Risk Management (FRM) Draft			VARQ FRM Refill							FRM Draft	
					Operate To Sturgeon Flow Objectives		Flow Augmentation Draft					
	Operate To Bull Trout Ramping Rates and Minimum Outflows											
Hungry Horse	Minimum Flow or VARQ FRM			VARQ FRM Refill								
	Variable Draft Limit (VDL)						Flow Augmentation Draft					
	Operate To Follow Bull Trout Ramping Rates and Maintain Minimum Flows At Columbia Falls and Downstream Of Dam											
Albeni Falls	Operate No Lower Than MCE			Refill			Full For Summer		Draft To Winter Pool (MCE)		No Lower Than MCE	
	Operate No Lower Than Kokanee Spawning Elevation										1/2 Foot Operating Band For Kokanee	
	Operate To Ramping Rates and Minimum Outflows											
Grand Coulee	FRM Draft and Refill								Resident Fish Operation			
	Operate For Chum and Vernita Bar			Operate To Support Hanford Reach Egress and Spring Migrants			Summer Flow Augmentation			Operate For Chum and Vernita Bar		
	VDL Operation To Provide 85% Probability Of Refill To April 10 FRM Elevation											
Dworshak				Spring Flow Augmentation			Summer Flow and Temperature Augmentation					
	Minimum Flow or FRM								Minimum Flow or FRM Draft			
						Refill To 1600'			Draft To 1535'		Draft To 1520'	

Legend FISH OPERATION FRM OR POWER OPERATION FISH AND POWER OPERATION OTHER PURPOSES

VARQ = variable discharge. FRM = Flood Risk Management. VDL = Variable Draft Limit. MCE = Minimum Control Elevation.

Figure 2-20. Storage projects operations timeline

The CRS flow objectives (Table 2-3) are intended to be used for pre-season planning and in-season water management. They are not, however, achievable in all years or periods because flow is largely dependent on annual and seasonal water conditions, including natural runoff volume and timing. The seasonal objective will be shaped each week for particular reaches through the Regional Forum including the TMT. To help meet the weekly flow objectives, the seasonal flow augmentation volumes in the storage projects will be used.

Table 2-3. Seasonal Flow Objectives and Planning Dates for the Mainstem Columbia and Lower Snake Rivers

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 The objective varies according to water volume forecasts for chum salmon (spawning begins approximately on November 1 and continues through December; protection flow objectives are based on the end of spawning redd locations downstream of Bonneville Dam and implemented from January 1 through emergence or April 10).

^b The objective varies based on actual and forecasted water conditions.
NA = not applicable.

The Action Agencies will seek to meet weekly flow requests that benefit migrants and spawners in the context of optimal overall use of available volumes in storage reservoirs. Responses to flow requests will also consider the needs of resident fish and other reservoir objectives. The Action Agencies will implement water management provisions that determine the actual managed flows that can be provided at a given time. For example, available storage will not necessarily be used to achieve weekly flow objectives if available storage would be prematurely depleted. Rather, available water would be distributed across the expected migration season to optimize biological benefits and fish survival.

Planning for storage project operations considers seasonal spring and summer flow objectives for ESA-listed fish, including the following actions:

- Operate storage projects to be at their FRM elevation targets in April (the exact date to be determined during in-season management) and to specific elevation objectives (for example, April 10 for Grand Coulee) to maximize flows for the spring outmigration of juvenile salmon.
- Attempt to 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. The Grand Coulee refill target will be reduced by the additional water supply amount and consistent with the implementation of the LRISRP (Appendix A and Appendix C) to limit impacts on spring flows.
- Manage CRS spill operations to minimize the water quality impacts.

- Draft storage projects to their August 31 or September 30 elevation targets based on water supply volume forecast.
- Provide fall and winter tailwater elevations/flows to support ESA-listed chum salmon spawning and incubation in the Ives Island area below Bonneville Dam, and to provide access for chum spawning in Hamilton and Hardy Creeks.
- Balance the consideration of these priorities for various listed fish (resident and anadromous).

Furthermore, the Action Agencies will continue to operate CRS storage projects to more closely approximate the shape of the natural hydrograph, enhance flows and water quality, and improve juvenile and adult fish survival where discretionary flexibility exists. Operations specific to each storage project and the system are described in the sections that follow.

LIBBY DAM

The VARQ FRM rule curves for Libby Dam were developed to reduce the draft for FRM in some years, thereby allowing for higher spring flows for juvenile anadromous fish migration in the Columbia River. The Action Agencies also store and supply water volumes and flows for sturgeon and bull trout based upon water availability. Another objective for Libby Dam operations is to minimize deleterious effects to the varial zone from a double peak by providing even or gradually declining flows following sturgeon flows during the summer months; this is determined through in-season coordination with the TMT. Refill timing at Libby Dam will be adjusted in season in consideration of available water supply, runoff shape, spring flow operations, FRM objectives (both at Bonners Ferry, Idaho, and system-wide), and will attempt to minimize spill to avoid exceeding the Montana State maximum TDG standard of 110 percent saturation, to the extent practicable.

During the late fall through late spring, Libby Dam operates the selective withdrawal gate system to discharge the coldest water available in the forebay of the reservoir for the benefit of migrating and spawning burbot in the Kootenai River in the Idaho reach of the river. Burbot are winter spawners and require cold water (optimal river temperature is 2 to 4°C) during spawning and egg incubation. The reservoir becomes isothermic (i.e., the same temperature near the surface and bottom of the lake) in mid-November and remains in this state through March during most years; therefore, thermal benefits associated with selective withdrawal gate placement are likely nominal during isothermy, and benefits to burbot occur coincidental to cold atmospheric conditions and low discharge (i.e., reduced volume results in reduced temperature as the water flows downstream and is exposed to the atmosphere).

During the summer months of July through September, the Action Agencies will operate Libby Dam to augment flows for juvenile salmon and steelhead outmigration in the Columbia River, and resident bull trout in the Kootenai River. The Action Agencies will use the best available forecasts to try to meet the goals of the summer draft, as coordinated with the TMT.

The trigger for summer draft from Libby Dam for downstream fish changes from past operations by changing the system forecast point (The Dalles Dam) to a local forecast point. Libby Dam will be operated based on local water supply conditions to allow water managers more flexibility to balance local resident fish priorities in the upper basin with downstream flow augmentation for the middle and lower basin. Water operations will be adjusted to end-of-summer elevation targets, which will be

generated based on conditions in the upper basin, rather than a flow forecast at the gage at The Dalles Dam.

Coordination of Libby Dam flow operations is discussed through the Regional Forum process, specifically with the TMT, and considers a number of factors when developing flows through the summer, including the impact of flow fluctuations on bull trout and other resident fish below the project, the status of juvenile salmon outmigration in the lower Columbia River, attainment of system and local flow objectives, in-river habitat improvement projects, and the potential effects of reservoir operations on other listed or resident fish populations downstream.

Operations for Kootenai River White Sturgeon Conservation

Kootenai River white sturgeon are affected by the Corps' operation and maintenance of Libby Dam. In the Proposed Action, the Action Agencies focus on managing the aquatic ecosystem by implementing a comprehensive and integrated set of measures, including operational measures and complementary habitat and hatchery actions to improve the reproduction and recruitment of Kootenai River white sturgeon and to address primary constituent elements for designated critical habitat. Libby Dam is operated to create flow and temperature conditions for sturgeon that are believed to enhance spawning habitat in river reaches upstream of Bonners Ferry over appropriate substrate. The results are intended to lead to natural recruitment of new individuals to the population and subsequent establishment of repeated natural production.

Flow

To increase the likelihood of sturgeon migration to appropriate spawning areas and to increase the probability of survival of eggs, larvae, and juveniles, Libby Dam will provide flow augmentation using a tiered set of volumes of water for sturgeon (Figure 2-21). Actual flow releases will be shaped according to in-season management of available water, in coordination with TMT and seasonal requests from the USFWS.¹⁰

The sturgeon flows will be measured above the 4,000 cfs minimum releases from Libby Dam. Accounting for these tiered volumes will begin when the regional team of biologists determines that benefits to the conservation of sturgeon are most likely to occur. Sturgeon volume accounting will also occur when additional flow above FRM flow is needed to sustain a base flow of 6,000 cfs from May 15 to May 31 (minimum bull trout flow), regardless of sturgeon augmentation commencement.

¹⁰ During a March 25–26, 2002 meeting, the Kootenai River White Sturgeon Recovery Team (which included members from the Action Agencies) determined that some problems could be corrected by establishing a new calculation for sturgeon flows. Release volumes are based on water availability, but the volumes to be released are calculated over the entire range of possible inflows (dashed line in Figure 2-22) rather than being grouped into the original six tiers.

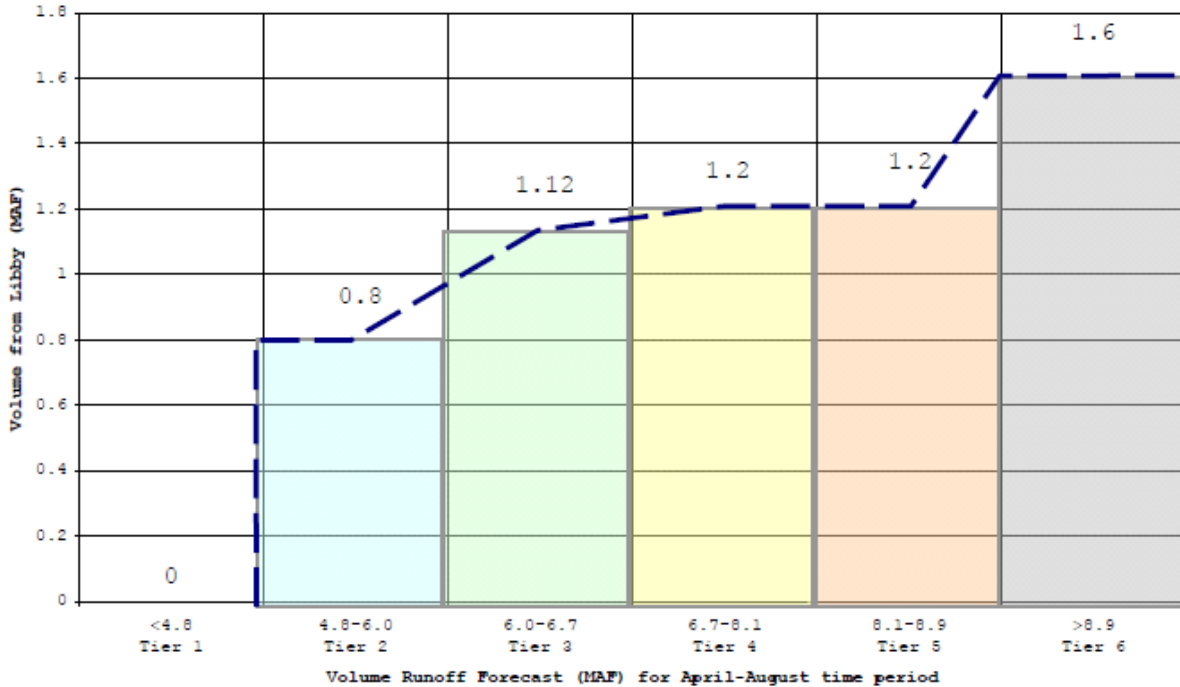


Figure 2-21. Tiered volumes of water for sturgeon flow enhancement to be released from Libby Dam, according to the May final forecast of April–August volume (Bonneville et al. 2014)

Temperature Management

Libby Dam is equipped with selective withdrawal gates that are operated to provide water temperature management for downstream aquatic biota, including fish. The Action Agencies will strive to manage to achieve steadily increasing release temperatures for sturgeon and avoid a sudden drop of more than 3.6°F (2°C) from Libby Dam during sturgeon incubation, hatching, and larval development phases. Currently, targets at Bonners Ferry are 50°F (10°C) minimum for sturgeon spawning and increase to no more than 64°F (18°C) in July and August for larval development. However, the Action Agencies will coordinate with the USFWS, Kootenai Tribe of Idaho (KTOI), IDFG, and Montana Department of Fish, Wildlife, and Parks (MFWP) to reassess the existing Selective Withdrawal Temperature Guidelines established by MFWP and the Action Agencies before the sturgeon listing. Generally, by long-standing agreement with MFWP, release temperatures within a seasonally fluctuating range are provided for protection and benefit of downstream biota; sturgeon temperature releases are consistent with this practice (Figure 2-22).

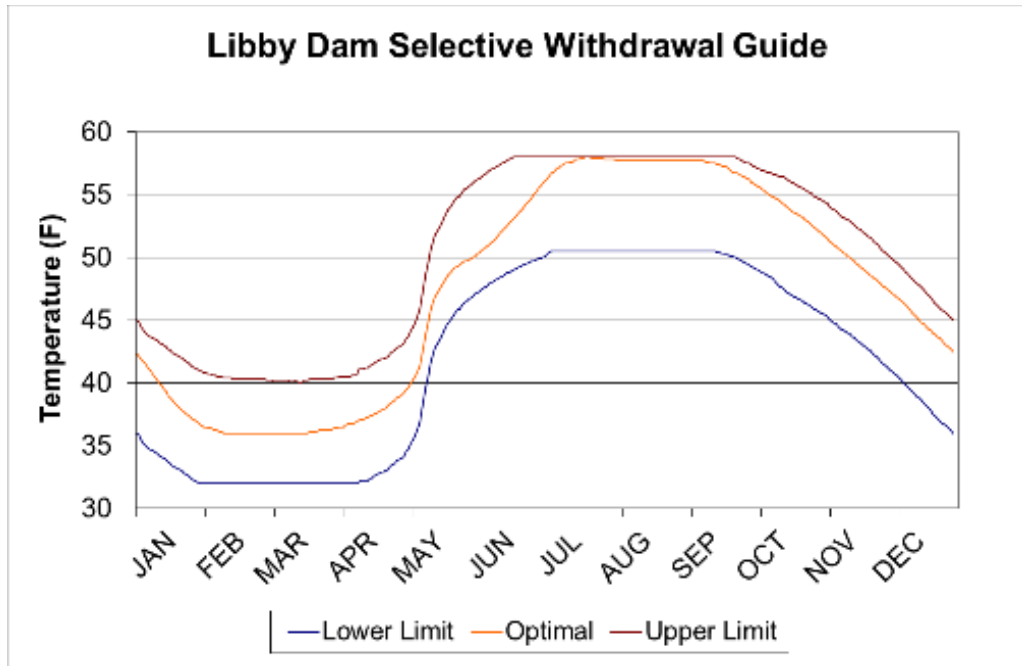


Figure 2-22. General temperature target range over the water year for Libby Dam flow releases

Lake Kootenai becomes isothermic in mid-November and remains in this state until April in most years. It is desirable to minimize winter temperature releases to minimize sturgeon metabolic rates, and thus minimize food demands and keep juveniles from starving in a food-scarce time of year; however, operational flexibility to alter the thermal regime is lacking because the lake is isothermic.

Water temperature profiles in the forebay will be monitored year-round to provide information necessary for optimizing river temperature before, during, and after flow augmentation for sturgeon spawning and rearing (BPA et al. 2019).

Coordinated Flows and Temperatures for Kootenai River White Sturgeon

- Based on the final April-to-August water volume supply forecast available in May, the Flow Plan Implementation Protocol (FPIP) technical team develops a recommendation for the shape, timing, and duration of expenditure of the tiered sturgeon volume, generally during late May into early June.
- The sturgeon augmentation flow will begin when the FPIP team determines that river conditions and sturgeon behavior are optimal for commencement of the operation. Steady or gradually declining releases after cessation of the sturgeon flow help establish and maintain varial zone production, while minimizing the possibility of abruptly dewatering established varial zone productivity.
- Release of the sturgeon volume will be accounted for over and above the 4,000 cfs year-round base flow.
- Selective withdrawal gates at Libby Dam are operated to more closely emulate a normative river temperature and flow relationship during the sturgeon pulse, and year-round as the forebay

thermal structure allows. Sturgeon spawning activity typically peaks as flow is receding and temperature is increasing.

- The total number of days at peak discharge will depend on real-time conditions.
- Libby outflows for sturgeon may reach full powerhouse capacity of about 25,000 cfs; flows at Bonners Ferry will be greater at times. Outflow from Libby Dam will be regulated to not exceed a stage of 1,764 feet, as much as possible, at the U.S. Geological Survey (USGS) Kootenai River gage at Bonners Ferry. Elevations at Bonners Ferry are affected by backwater from Kootenay Lake. There may be extreme cases when Libby Dam is regulated for another target chosen to balance downstream flood stages and control refill of Lake Koocanusa (Corps 1999).

Kootenai River White Sturgeon Operational Decision Processes

Testing hypotheses regarding the relationship among flow, temperature, and volitional movement of spawning-condition sturgeon to suitable spawning habitat is an essential part of the annual operational considerations. Thus, this plan proposes to continue to implement the FPIP protocol, as described above, to inform sturgeon operations. The criteria to be considered and met when planning for these flow and temperature operations include reservoir and river temperatures, river elevation at Bonners Ferry, location of the river/lake backwater interface as it relates to Kootenay Lake elevation, and other physical river conditions important to sturgeon migration and spawning behavior that are currently being assessed. Operations for Kootenai River white sturgeon are managed at or above 30 kcfs at Bonners Ferry, Idaho, for as long as possible, and temperature considerations are associated with selective withdrawals and temperature stratification. Sturgeon response to these actions will be confirmed through monitoring and evaluation (M&E) (see Section 2.6.2.4).

In-season Management for Kootenai River White Sturgeon Conservation

The actual operation of reaching the summer draft targets is achieved in season and is coordinated through the TMT. The planning and implementation of these releases are guided in the spring by the FPIP technical team. The FPIP technical team consists of representatives of the Corps, Bonneville, USFWS, KTOI, Confederated Salish and Kootenai Tribes (CSKT), IDFG, MFWP, and others. The FPIP technical team will develop a recommendation for the USFWS in the form of a pre-season flow implementation plan based on results of previous operations and current and forecasted water supply (tiered volume, as shown in Figure 2-21) and reservoir elevation (thermal consideration). The USFWS will provide System Operation Requests for discussion by the TMT and decision-making by the Corps. During in-season operations, which can occur from April through mid-June, weekly conference calls will be held with the affected parties, including representatives from the FPIP technical team and other entities interested in sturgeon flow and temperature management. During the calls, updates on flow and temperature conditions, sturgeon behavior, monitoring, and hatchery operations will be shared and considered to inform any needed actions during the ensuing week.

Operations for Bull Trout Conservation

Minimum Flows

The Action Agencies will continue to provide the minimum flows from Libby Dam (measured at the USGS gage on the Kootenai River below Libby Dam and listed in Table 2-4), if possible, within project operational constraints. The Action Agencies will provide minimum bull trout flows of 6,000 cfs May 15 through September, and up to 9,000 cfs after the sturgeon pulse through August 31 (Table 2-4). This will protect the channel inundated at this flow during the most biologically productive period of the year.

Table 2-4. Minimum water releases for bull trout from Libby Dam May 15 through September 30

Water Supply Forecast Runoff Volume (MAF) at Libby	Minimum Bull Trout Flows (cfs) Between Sturgeon and Salmon Flows
0.00 < forecast < 4.80	6,000
4.80 < forecast < 6.00	7,000
6.00 < forecast < 6.70	8,000
6.70 > forecast	9,000

Note: Table content is based on the May final Libby water supply forecast for the April–August period (minimum is 6,000 cfs from May 15–June 30 and all of September) (BPA et al. 2019)

Ramping Rates and Daily Shaping

To maintain varial zone productivity and habitat stability and to avoid stranding bull trout, the recommended ramping rates (Table 2-5) will be followed unless the recommended ramping rate causes a unit(s) to operate in a manner that increases vibration and cavitation that could result in premature wear or failure of the units. In this case, the project will use a ramping rate that allows all units to operate while minimizing the risk of damage to the units. Ramping rates to minimize impacts on fish and wildlife resources for both ramp-up and ramp-down operations will be followed to the extent possible during project operations. Table 2-5 provides the starting flow, the hourly increment of allowable change, and the units or flows affected.

From October through February, daily load shaping may occur to maintain FRM requirements or optimize power production. Limiting daily load shaping during October through February to above the minimum flow of 6,000 cfs within the ramping rate constraints (Table 2-5) provides a minimal amount of protected foraging, migration, and overwintering (FMO) habitat while enabling hydropower generation flexibility.

See Section 2.6.2 for the non-operational conservation measures for Kootenai River white sturgeon and Section 2.6.3 for bull trout at Libby Dam.

Table 2-5. Daily and hourly maximum ramping rates for Libby Dam^a

Ramp Direction	Starting Flow	Hourly	Daily
Summer (May 1–September 30)			
Ramp Up	4–6,000 cfs	2,500 cfs	1 unit
	6–9,000 cfs	2,500 cfs	1 unit
	9–16,000 cfs	2,500 cfs	2 units
	16,000 cfs-Q _{PHC} ^b	5,000 cfs	2 units
Ramp Down	4–6,000 cfs	500 cfs	500 cfs
	6–9,000 cfs	500 cfs	1,000 cfs
	9–16,000 cfs	1,000 cfs	2,000 cfs
	16,000 cfs-Q _{PHC} ^b	3,500 cfs	1 unit
Winter (October 1–April 30)			
Ramp Up	4–6,000 cfs	2,000 cfs	1 unit
	6–9,000 cfs	2,000 cfs	1 unit
	9–16,000 cfs	3,500 cfs	2 units
	16,000 cfs-Q _{PHC} ^b	7,000 cfs	2 units
Ramp Down	4–6,000 cfs	500 cfs	1,000 cfs
	6–9,000 cfs	500 cfs	2,500 cfs
	9–16,000 cfs	1,000 cfs	1 unit
	16,000 cfs-Q _{PHC} ^b	3,500 cfs	1 unit

^a As measured by cumulative daily flow changes within the 24-hour period (mid-night to mid-night, not daily averages), restricted by hourly rates.

^b Q = discharge or flow; PHC = powerhouse capacity.

HUNGRY HORSE DAM

Reclamation balances operations at Hungry Horse Dam for authorized purposes and other operations including operations to benefit both resident and anadromous ESA-listed species. When not operating for FRM or releasing water for flow augmentation to benefit anadromous fish, Hungry Horse Dam is operated to meet minimum flows both below the dam on the South Fork Flathead River and at Columbia Falls on the mainstem Flathead River to benefit bull trout.

Variable Draft Limits (VDLs) have been developed to allow flexibility for power generation while ensuring a 75 percent probability of meeting the April 10 elevation objective, which is to maximize flow released between April 10 and June 30 to benefit juvenile anadromous fish migration. Ramping rate limits were established below Hungry Horse Dam to reduce the likelihood of fish becoming stranded.

Reclamation attempts to refill Hungry Horse Reservoir by June 30, but the timing and shape of the spring runoff may result in commencing reservoir refilling before or after the June 30 target date. The

June refill benefits resident bull trout in the reservoir while maximizing the water available for release for summer flow augmentation to support juvenile anadromous fish migration in the Columbia River.

In this Proposed Action, the trigger for summer draft from the Hungry Horse project for downstream fish will change from a system forecast point to a local forecast point. Water operations would be adjusted to end-of-summer elevation objectives, which would be generated based on conditions in the upper basin, rather than on a flow forecast at the gage at The Dalles Dam. Hungry Horse Dam will be operated based on local water supply conditions to balance local resident fish priorities in the upper basin with downstream flow augmentation for the middle and lower basin.

Every attempt will be made to either release this water evenly or gradually decline flows from July through September to minimize a double peak of flow on the Flathead River. In some years the project is drafted below the end-of-September draft target to support minimum flow releases for resident fish. There are two minimum flow requirements for Hungry Horse Dam (Table 2-6). One is for the South Fork Flathead River below the project, and the second is for Columbia Falls on the mainstem Flathead River located just downstream from the confluence of the south fork with the mainstem. The minimum flows for both sites are determined monthly based on the Reclamation water supply forecast for the inflows to Hungry Horse Reservoir for the period from April 1 through August 31. These minimum flows are determined monthly starting with the January forecast, and then are set for the remainder of the year based on the March final runoff forecast. (These operations are discussed in more detail in Appendix A).

Hungry Horse operations are communicated to Energy Keepers Inc., the operators of Séliš Ksanka Qíispé (SKQ) Dam on Flathead Lake downstream from Hungry Horse Dam, to provide inflow information for Flathead Lake. During low water years, there may be insufficient water for SKQ Dam operators to achieve FERC license Article 43 lake levels at Flathead Lake and to maintain the flow requirements below Flathead Lake. In these type of years, Hungry Horse releases for flow augmentation may be shaped, when possible, to assist SKQ Dam operators in meeting license requirements under Federal Power Act Section 4(e), and to maintain Flathead Lake at a higher elevation during the summer. These operations are secondary to Hungry Horse Dam fish operations for bull trout and anadromous fish, and do not result in double peaking flows or a change in the end-of-September pool elevation targets. Coordination of Hungry Horse flow operations is also discussed by the TMT using the Regional Forum process, which weighs considerations unique to each particular year.

Operations for Bull Trout Conservation

Minimum Flows

Minimum releases at Hungry Horse Dam were developed to benefit bull trout, and other resident fish and aquatic life, and are determined by either the flow requirement on the South Fork Flathead River below Hungry Horse Dam or the flow requirement on the mainstem Flathead River at Columbia Falls, whichever is greater. The minimum flows are calculated using the Hungry Horse inflow forecast and guidelines as set forth in Table 2-6. The minimum flows at Hungry Horse Dam and Columbia Falls are updated every month between January and March after the final inflow volume forecast for the month is issued. The March final forecast sets the minimum flows for the rest of the calendar year.

Table 2-6. Minimum flows in the South Fork Flathead River (Hungry Horse) and mainstem Flathead River (Columbia Falls)

April through August Forecast	Minimum flow
At Hungry Horse Dam	
>1.79 MAF	900 cfs
<1.19 MAF	400 cfs
Between 1.19 MAF and 1.79 MAF	Linearly interpolated between 400 and 900 cfs
At Columbia Falls	
>1.79 MAF	3,500 cfs
<1.19 MAF	3,200 cfs
Between 1.19 MAF and 1.79 MAF	Linearly interpolated between 3,200 and 3,500 cfs

Ramping Rates

The rate of changes in Hungry Horse discharges is limited by ramping rates, as described in Table 2-7. These ramping rates were established to limit flow variability and minimize impacts on resident bull trout and are based on flows in the Flathead River at Columbia Falls. These ramping rate guidelines are designed to protect bull trout and other fish from becoming stranded.

Table 2-7. Ramping rate guidelines at Hungry Horse Dam

Flow Range (measured at Columbia Falls)	Ramp-Up Unit (Daily Max)	Ramp-Up Unit (Hourly Max)
Ramp-Up Rates		
3,500-6,000 cfs	Limit ramp up 1,800 cfs per day	1,000 cfs/hour
>6,000-8,000 cfs	Limit ramp up 1,800 cfs per day	1,000 cfs/hour
>8,000-10,000 cfs	Limit ramp up 3,600 cfs per day	1,800 cfs/hour
>10,000 cfs	No limit	1,800 cfs/hour
Ramp-Down Rates		
3,500-6,000 cfs	Limit ramp down to 600 cfs per day	600 cfs/hour
>6,000-8,000 cfs	Limit ramp down to 1,000 cfs per day	600 cfs/hour
>8,000-12,000 cfs	Limit ramp down to 2,000 cfs per day	1,000 cfs/hour
>12,000 cfs	Limit ramp down to 5,000 cfs per day	1,800 cfs/hour

Temperature Management

Reclamation placed selective withdrawal gates on the penstocks at Hungry Horse Dam, which have warmed the South Fork Flathead River since 1995 (Marotz et al. 1994; Vermeyen 2006). These gates are used to provide warmer epi-limnetic water (water layer near the surface of a lake or reservoir that is

warmer in the summer) to the river during the summer period when the reservoir is stratified. By agreement with MFWP, Reclamation operates the gates to achieve a temperature regime in the river that is as similar as possible to natural conditions. The purpose of this manipulation was to prevent the very cool (4°C hypo-limnetic waters) from suppressing the primary and secondary production in the river and to prevent the cold-water plume, which formerly extended downstream in the mainstem Flathead River, from acting as an attractant to non-native lake trout moving from Flathead Lake upstream, which may increase the predation pressure on native cutthroat and bull trout.

Total Dissolved Gas

Hungry Horse Dam is operated to the extent possible to minimize spill and generation of TDG. Although the generation capacity of Hungry Horse Dam is about 428 MW, there is a generation limit at the dam of 310 MW (about 9,000 cfs) due to transmission limitations in the Flathead Valley. Releases greater than 9,000 cfs must be put through the hollow jet flow valves, which can generate elevated levels of TDG. Empirical data and estimates indicate that limiting spill to a maximum of 15 percent of total outflow will help avoid exceeding the Montana State TDG standard of 110 percent saturation. When spill is anticipated to exceed 15 percent of total outflow, Reclamation attempts, to the extent possible, to pre-draft or reshape drawdown and refilling operations to minimize spill and excess TDG generation.

Reservoir Elevations

Before 1995, reservoir drawdown and subsequent filling created a large variable zone along the shoreline of the reservoir where vegetation was limited because of varying water levels. This lack of vegetation and woody debris limited the establishment of cover for rearing juvenile bull trout, but suitable rearing habitat was available in spawning tributaries that discharge to Hungry Horse Reservoir. The 1995 NOAA Fisheries Biological Opinion (BiOp) (NMFS 1995) established an April 20 elevation objective and eliminated the deep power drafts. In 2002, Reclamation adopted the VARQ (variable flow) FRM operating regime. This regime further reduced deep drafts for FRM in some years and maintains more stable reservoir elevations during the peak spring and summer primary productivity seasons (NPCC 2004).

During the summer season, Reclamation's operating priorities are flow augmentation for anadromous fish downstream of Chief Joseph Dam, and minimum flows and refilling for resident fish. In accordance with the Northwest Power and Conservation Council's (NWPPCC's) 2003 mainstem amendments recommendation, Hungry Horse Dam will be operated to balance flow augmentation with storage for resident fish. In wetter years, refilling can be delayed until mid-July. After the refilling period, Hungry Horse Dam releases are set to meet the September 30 elevation objectives (Table 2-8). These reservoir operations reduce water level fluctuation during the summer and fall, which overlaps with the primary period when bull trout are migrating to spawning habitat in tributaries. This limits the extent of the variable zone and associated habitat fragmentation in these migratory corridors. In some years the project is drafted below the end-of-September draft target to support minimum flow releases for resident fish.

Table 2-8. End-of-September elevation draft limits for summer flow augmentation at Hungry Horse Dam

Local Water Supply Forecast^a	Driest 10% of Years	Interpolate for Water Supply Between the Driest 10 to 20%	Wettest 80%
End-of-September elevation objective feet)	3,540 feet	3,540 to 3,550 feet	3,550 feet

^a Based on the May final Reclamation Hungry Horse water supply forecast for May to September. The 10th percentile, or 10% driest years, is currently approximately 1.15 MAF, and the 20th percentile is currently approximately 1.31 MAF—both based on the current official 30-year period of 1981 to 2010. In early 2020, these values will be updated based on the next official 30-year period from 1991 to 2020.

Double Peak

When transitioning from FRM operations to release of flow augmentation, Reclamation attempts to operate Hungry Horse Dam to release steady or gradually declining outflows from July through September. This reduces the probability of creating a double peak at Columbia Falls on the mainstem Flathead River below Hungry Horse Dam. The double peak occurs when discharges are reduced at the end of FRM operations to allow refilling of the reservoir, then the discharges are increased to release water for flow augmentation. To the extent possible, Hungry Horse Dam is operated to gradually transition between refilling and flow augmentation releases to prevent this dip in flows.

ALBENI FALLS DAM

The fall storage drawdown at Albeni Falls Dam occurs from September to mid-November. The objective is to prepare for flood season, draft for power in the fall, and provide a relatively stable lake elevation to improve non-ESA-listed kokanee redd survival during the spawning period (generally sometime between November 15 and December 31). The storage draft of the lake in the fall may also contribute to the support of flows in early November for chum salmon in the lower Columbia River, which are listed as threatened under the ESA. An MCE of 2,051 feet is provided from December 1 to March 31, to provide a means of protecting kokanee spawning and egg incubation, as well as flood risk reduction and flexibility in power operations during the winter. In coordination with IDFG, Action Agencies transition to winter power operations after the completion of kokanee spawning. (For additional details, see Section 2.3.1.4).

GRAND COULEE DAM

Reclamation balances operations at Grand Coulee Dam for authorized purposes and to benefit both resident and anadromous ESA-listed species. VDLs have been developed to balance flexibility for power generation with the objective to assure an 85 percent probability of meeting the April 10 elevation objective to benefit juvenile anadromous fish migration.

During spring or early summer in higher water years, when required releases exceed the power demand, water must be spilled (bypass the turbines) at Grand Coulee Dam. Reclamation tries to avoid spilling

water at Grand Coulee Dam when the reservoir is below the elevation of 1,265.5 feet because this requires spilling through the outlet tubes, which generates significant TDG; above the elevation of 1,265.5 feet, water can pass over the spillway, which produces less TDG. Using the 80-year period of record modeling the outlet tubes are used approximately 58% of the years this model also showed that and TDG below Grand Coulee exceeds 120% in 38% of years, for about 2% of the total days. Spill at Grand Coulee Dam is managed in coordination with the Corps' Chief Joseph Dam to reduce TDG generation. Flow deflectors on the spillways at Chief Joseph Dam reduce generation of TDG and are efficient at stripping and reducing TDG in water spilled below Chief Joseph Dam. To the extent possible, generation is shifted to Grand Coulee Dam and spill is shifted to Chief Joseph Dam to minimize TDG generation (see the discussion of Chief Joseph Dam in Section 2.3.2.6).

Reclamation typically targets refilling after the Fourth of July holiday, but in wetter water years, refilling can be delayed until mid-July to manage flows in the lower Columbia River. The refill elevation objective is adjusted to reduce impacts on spring flows consistent with the Lake Roosevelt Incremental Storage Release Project, in addition to the LRISRP adjustment Reclamation will reduce impacts from future water supply development on spring flows by missing refill (Appendix A). Reclamation drafts Lake Roosevelt to 1,280 or 1,278 feet by the end of August to provide flow augmentation for anadromous fish in the Columbia River. In addition, under the Lake Roosevelt Incremental Storage Release Program, Lake Roosevelt will be drafted an additional foot in most years and an additional 1.8 feet in drought years (as defined by the state of Washington) when the program is fully implemented. One-third of the water drafted goes to instream flows between April 10 and August 31. Banks Lake will be allowed to draft 5 feet from full (elevation 1570 feet) to an elevation of 1,565 feet by the end of August to provide more water for summer flow augmentation. This is accomplished by reducing pumping to Banks Lake and allowing irrigation deliveries for the Columbia Basin Project to draft Banks Lake to an elevation of 1565 feet by August 31. Reclamation attempts to operate Grand Coulee Dam and Lake Roosevelt to refill to an elevation of 1,283 feet by September 30 at the request of tribes to aid resident fish, including access to shoreline and tributary habitat. To maintain power generation flexibility, the Lake Roosevelt elevation objective of 1,283 feet or higher by the end of September may be delayed to no later than the end of October. Delaying refilling to an elevation of 1,283 feet allows more operational flexibility for hydropower generation by relaxing restrictions on seasonal pool elevations at Grand Coulee Dam. In most years, meeting the targeted elevation of 1,283 feet by the end of September is anticipated, but in drier years when the summer flow augmentation objective is 1,278 feet (at the end of August) refilling to 1,283 feet affects hydropower generational flexibility. In these years, the requirement is not until the end of October, but the project will be operated to refill to an elevation of 1,283 feet as soon as practical.

Communication with the tribes will occur so any concerns can be addressed through Bonneville's Fish and Wildlife Program. To make the most of available funds, investments in fish and wildlife protection, mitigation, and enhancement will be prioritized based on biological and cost-effectiveness and their connection to mitigating for impacts of the CRS operations.

Attempts are made to refill Lake Roosevelt by the end of October, ideally to approximately an elevation of 1,288 feet in anticipation of winter operations for chum and power generation. Grand Coulee Dam may release water in the fall for spawning of chum below Bonneville Dam, and in the winter and spring

for protection flows for both chum below Bonneville Dam and for fall Chinook below Priest Rapids. Grand Coulee also supports flow objectives in the Hanford Reach (Vernita Bar).

Coordination of Grand Coulee flow operations are discussed with the TMT using the Regional Forum process, which addresses considerations unique to each particular year.

DWORSHAK DAM

Dworshak Dam is operated to end-of-month FRM elevations from January through April. Opportunities to shift system FRM requirements from Dworshak Dam to Grand Coulee Dam will be considered periodically from January through April. VDLs have been developed to balance the flexibility for power generation with the objective to assure a 95 percent probability of meeting the April 10 elevation objective to benefit juvenile anadromous fish migration. Additionally, the Corps operates the project during the spring to maintain a 95 percent probability of refilling by about June 30. The reservoir is deemed to be full at elevations of 1,599 feet or more. Refilling is managed to also maximize the release of stored water from Dworshak Dam, in order to provide water for meeting the lower Snake River flow objectives for outmigrating salmon and steelhead. The project may release additional flows, if necessary, to move juvenile fish into the mainstem Clearwater River during spring hatchery releases.

Summer flow augmentation is provided by Dworshak Dam to improve water quality (moderating river temperatures) and increase water velocities in the lower Snake River. The summer temperature moderation and flow augmentation releases from Dworshak Dam are shaped with the intent to maintain water temperatures at or below 68°F at the fixed monitoring site at the Lower Granite Dam tailrace.

The objective of the Action Agencies is to draft to an elevation of 1,535 feet by the end of August and an elevation of 1,520 feet (80 feet from full) by the end of September, unless modified per the agreement between the United States and the Nez Perce Tribe (NPT Agreement) for water use in the Dworshak Reservoir. On September 1, the project begins to release flow augmentation water under the NPT Agreement with up to 200,000 acre-feet of water stored in the reservoir (storage between elevations of 1,535 feet and 1,520 feet). The extension of the draft limit into September assures that water will be released consistent with the NPT Agreement. Releases under the NPT Agreement will be determined in the annual plan prepared by the Corps, NOAA Fisheries, Nez Perce Tribe, the state of Idaho, and Bonneville, and presented to TMT for implementation.

The Corps' Dworshak Fish Hatchery, downstream of Dworshak Dam (operated by the USFWS and the Nez Perce Tribe), requests dam releases to provide the preferred water temperatures during various times of the year. The primary water supply for the Dworshak National Fish Hatchery is provided by pumps on the North Fork Clearwater River, and water temperatures for the hatchery can be adjusted by using the selector gates on the turbine intakes. However, operations at the Dworshak Dam water temperature control structure have a limited ability to maintain target temperatures, especially during minimum flows. Releases for optimum water temperatures for the hatchery are affected during the summer because the primary emphasis of dam releases are for Snake River flow and temperature augmentation consistent with NOAA's BiOp.

Coordination of Dworshak flow operations is discussed with the TMT using the Regional Forum process, which addresses considerations unique to each particular year.

2.3.2.2 Chum Spawning Flows

To provide adequate conditions for chum spawning in the mainstem Columbia River below Bonneville Dam in the area of the Ives Island complex or access for spawning in Hamilton and Hardy Creeks, or both, the Action Agencies will provide a Bonneville Dam tailwater elevation of approximately 11.5 feet (MSL) beginning the first week of November (or when chum arrive) and ending in late December, if water supply in the fall is insufficient and chum have not arrived, the start of the operation may be delayed to the second week or later in November or as decided in TMT. This operation is contingent on reservoir elevations and water supply conditions indicating that the tailwater elevation can be maintained through the incubation and emergence life stages. If water supply is deemed insufficient to provide adequate mainstem spawning or continuous tributary access, the Action Agencies will provide, as appropriate, intermittent mainstem flow to allow chum access to adequate tributary spawning habitat, if available. In coordination with TMT, the Action Agencies will adjust the Bonneville tailwater elevation consistent with the size of the spawning population and water supply forecasts.

After chum spawning ends, the Action Agencies will manage tailwater elevation, if possible, to protect mainstem chum redds through incubation and the forecasted end of emergence or April 10, whichever occurs first.

The Action Agencies will revisit the chum-protection-level decision at least monthly using the TMT process to assure it is consistent with the need to provide spring flows for ESA-listed Columbia and SR salmon and steelhead species.

2.3.2.3 Forecasting and Climate Variability

The Action Agencies will continue to work collaboratively with the Columbia River Forecast Group to promote and support improved forecasting skills, products, and techniques in the Columbia River Basin, with the goal of improving storage project operations for the benefit of the Pacific Northwest. The group provides an avenue for sharing, discussing, evaluating, and potentially implementing new forecasting techniques for CRS planning and operation. The group also coordinates with the River Management Joint Operating Committee (RMJOC) and provides a technical review of the RMJOC-II project climate variability streamflow data sets. In June 2018, the University of Washington published the unregulated streamflow data set from the RMJOC-II project (RMJOC 2018); the final RMJOC-II data set is scheduled for completion in 2020.

2.3.2.4 Columbia River Treaty Storage

To provide additional water for anadromous fish flows, the U.S. Entity under the Columbia River Treaty (i.e., the Corps and Bonneville) has coordinated with the Canadian Entity (BC Hydro) for the use of available Canadian storage in the Columbia River Treaty projects. Use of Columbia River Treaty storage for fish purposes is contingent on development of mutually beneficial agreements between the U.S. and Canadian Entities. In recent annual Treaty agreements, the Canadian Entity has provided storage of flow augmentation water (1.0 MAF) for U.S. fish benefits in exchange for flow-shaping to meet fish objectives in Canada. The 1.0 MAF is released within the May-through-July period to benefit fish in the United States.

2.3.2.5 Non-Treaty Storage Agreement

Use of space in Canadian reservoirs not included in the Treaty, referred to as non-Treaty storage, has required the negotiation of additional agreements between Bonneville and BC Hydro. Bonneville and BC Hydro executed a long-term Non-Treaty Storage Agreement effective April 10, 2012 through September 15, 2024. The agreement allows use of non-Treaty storage space in Canada to shape flows within existing downstream requirements and to create additional mutual power and non-power benefits for both parties. The agreement was crafted to assure that non-Treaty storage operations in Canada comply with the Columbia River Treaty requirement that power and flood risk management benefits under Treaty may not be reduced by non-Treaty operations. Under terms of the agreement, either party may limit transactions to protect power or non-power requirements, such as FRM and fish, except for dry-period firm-release rights. Under the agreement, Bonneville has a firm-release right of up to 0.5 MAF of water in the spring to benefit fish in the lowest 20th percentile of water conditions (measured at The Dalles) if not used in the prior year. In addition, the agreement provides the opportunity with mutual concurrence to store water when it is abundant and exceeds fish objectives and/or state standards for TDG levels in the spring, and then release that water in the summer to provide water when the Columbia River flows are typically lower. Storage project operations under the Non-Treaty Storage Agreement are included in the annual WMP and coordinated with the TMT.

2.3.2.6 Run-of-River Project Operations for Fish and Wildlife Conservation

MIDDLE COLUMBIA RIVER PROJECT – CHIEF JOSEPH DAM

Chief Joseph Dam is a run-of-river project immediately downstream of Grand Coulee Dam. The project is operated primarily for generation of hydropower but also provides a key system TDG management function. Flow deflectors were installed on the 19 spill bays at Chief Joseph Dam in 2008 for the purpose of reducing TDG levels in the river to lessen impacts on aquatic life. This allows for maintaining power generation at Grand Coulee Dam while Chief Joseph Dam spills water as necessary. When Grand Coulee spill increases and TDG concentrations in the Chief Joseph Dam forebay exceed 117 percent saturation, the spillway flow deflectors can reduce TDG concentrations (i.e., TDG concentrations in Chief Joseph forebay that exceed 130 percent saturation can be reduced to about 120 percent saturation in spilled water below Chief Joseph Dam). This protects aquatic life, including steelhead and bull trout critical habitat, which extends upstream from John Day Dam to Chief Joseph Dam in the mainstem Columbia. This also benefits fish in Chief Joseph Reservoir (Rufus Woods Lake; not part of bull trout critical habitat), because the likelihood of spill at Grand Coulee Dam and associated elevated TDG levels downstream is reduced.

In 1981, the Corps raised the normal full pool level of Rufus Woods Lake by 10 feet, from 946 to 956 feet MSL, to increase hydropower capacity at Chief Joseph Dam. Under authority of the Fish and Wildlife Coordination Act of 1958 (72 Stat. 563 1958), the Corps entered into a 30-year contract to work with the Washington Department of Fish and Wildlife (WDFW), Colville Confederated Tribes (CCT), and USFWS to develop a comprehensive wildlife mitigation plan to preserve existing habitat for wildlife species and mitigate wildlife habitat losses caused by the 10-foot increase in elevation. For example, during the goose nesting season from February 15 through May 15, maintaining a minimum elevation of 950 feet at Chief Joseph Dam is important for inhibiting the formation of land bridges to nesting sites at

lower elevations; land bridges result in increased predation of young birds. A 25-year M&E program was recently completed, and the future direction of the mitigation program was evaluated by the Corps, CCT, WDFW, and USFWS. A newly proposed Habitat Management Plan (HMP) will act as a guideline for continued mitigation of lost riparian habitat. The HMP will refocus on current species of concern, such as sharp-tail grouse and removal of noxious weeds (e.g., Russian olive, blackberries, and black locust).

FLEXIBLE SPILL OPERATION WITH ADAPTIVE MANAGEMENT

The flexible spill operation (flex spill) is an operation that would be implemented during the spring juvenile salmonid migration season at the lower Snake River projects and the lower Columbia projects. Flex spill is variable over a 24-hour period and takes advantage of peak and off-peak load hours for hydropower. Flex spill is envisioned to incorporate a range of spring spill levels up to a 125% TDG spill cap¹¹ during designated hours each day, consistent with the concepts tested as part of the 2019–2021 Spill Operations Agreement (Corps et al. 2018). The intent of the operation will be to meet shared “performance targets” for fish, power generation/transmission, and other operational considerations developed through collaboration through the Regional Forum.

The baseline operation (e.g., proposed in 2020) is that over the course of a 24-hour period, 16 hours would be operated to spill up to the 125% gas cap for juvenile outmigration. For the remaining 8 hours, the projects would spill at a lower level (referred to as performance standard spill¹² and estimated by project location in Table 2-10 below). These spill levels are slightly variable, depending on the project, and may be slightly higher or lower, depending on river conditions and the opportunity to spill. This operation would allow hydropower generation during times of peak demand, while still providing high spill for juvenile fish when spill is expected to be most important. The priority is to provide for spill for juvenile salmonids, and this spill level would be implemented when juvenile fish are known to migrate, generally in the evenings and very early morning hours. These operations would be implemented April 3–June 20 at the lower Snake River projects, and April 10–June 15 at the lower Columbia projects. When flex spill ceases, the projects will transition to summer spill operations.

Attempts will be made to minimize in-season changes to the proposed operations, but if serious deleterious impacts are observed (e.g., potential delays to adult migration, river flows, or effects on navigation), operations may be adjusted. The Corps will coordinate these changes and decisions through established Regional Forum, for example, the TMT, FSWG, and RIOG. If delays in adult salmon, steelhead, or bull trout passage are observed, operations would revert to performance standard spill until the adults pass the dam.

The Action Agencies will use existing GBT monitoring and adaptive management protocols for juvenile salmon to determine if GBT thresholds have been exceeded. If thresholds have been exceeded, and if river conditions allow, the Action Agencies will reduce spill, where appropriate, in accordance with state

¹¹ Pending the conclusion of the states of Oregon and Washington’s water quality standard processes.

¹² “Performance standard” spill is a NOAA Fisheries term that refers to the spill level intended to meet NOAA’s performance standard testing, as described in the 2008 FCRPS Biological Opinion and accompanying Administrative Record.

water quality standards. The Action Agencies, in coordination with the FSWG (which includes the Services), will determine specific operational changes.

Contingency Reserves in Juvenile Fish Passage Spill

Having contingency reserves in fish spill would allow operations to change fish spill for short durations during the fish passage spill season. This change would be implemented to meet energy demands that are caused by unexpected events such as transmission interruption or the failure of a generator. These events are rare and, when they occur, the Action Agencies may be able to cover the contingencies without temporarily reducing spill. This measure would provide operating flexibility to allow Bonneville to carry required reserves on the turbines to assure grid reliability. This measure would be implemented at all lower Snake River and lower Columbia River projects during the fish spill season.

Adaptive Implementation Framework

The Adaptive Implementation Framework (AIF) *for the Flexible Spill Operational Component of the Columbia River System Operations* has been established to maintain the three original objectives of the spring and summer spill operations agreed upon in the 2019–2021 Spill Operation Agreement (i.e., power, fish benefits, and safe implementation of operation by the Corps). Given the longer-term nature of the proposed operations and acknowledging the uncertainties over how fish will respond, the Action Agencies propose the addition of a fourth objective. The fourth objective is to create a robust study design that can provide statistically meaningful results within a reasonable management timeframe. The analysis of future scenarios and the adaptive implementation of future operations will be considered while meeting the four objectives.

The AIF is intended to set up the initial steps in the development of a strategy to develop, implement, and monitor spill operations through coordination with federal, state, and sovereign parties with the goal of assessing the magnitude of latent mortality associated with juvenile salmonid passage through the CRS projects on the lower Snake and lower Columbia Rivers. The intent is, without ceding the decision-making authorities of each Action Agency, to develop a transparent, collaborative process where regional experts will work with the Action Agencies to develop and monitor an operation that yields scientifically robust information to inform the efficacy of the proposed action. By following this AIF, the Action Agencies will collaborate with the regional experts, while maintaining the ability to adapt to new information and respond to unanticipated outcomes or challenges that may arise as a result of testing the magnitude of latent mortality. The AIF will be managed through established Regional Forum and processes. These provide a predictable governance structure from which to vet technical to policy level guidance and decisions. For example, Corps funded research will be planned and evaluated thru the SRWG; in-season operational changes to the FPP will be coordinated thru the FPOM work group and TMT; issues not resolved by the TMT will be elevated to the FSWG; and issues not resolved by the FSWG will be elevated to the RIOG. See Section 2.1, Regional Coordination for a description of the Regional Forum and their respective roles and responsibilities.

LOWER SNAKE RIVER PROJECTS

The Action Agencies will operate the lower Snake River projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams) in accordance with annual WMPs¹³ and Fish Passage Plans¹⁴ (FPPs; including all appendices). The FPP is developed annually by the Corps in coordination with Bonneville and regional federal, state, and tribal fish agencies. The FPP describes year-round operation and maintenance activities at Corps dams on the Columbia and Snake Rivers. Detailed criteria and guidelines for lower Snake River project operations are included in the annual WMP and FPP.

The lower Snake River dams are run-of-river projects operated for multiple purposes, including fish and wildlife conservation, incidental irrigation, navigation, hydropower generation, and recreation. The projects also have the potential to be operated for limited FRM under special circumstances. They are equipped with structural fish passage facilities. Structural features for juvenile fish passage include surface spill structures, juvenile bypass systems (JBSs), and improved JBS outfalls at all the lower Snake River dams. Operations for juvenile salmonids at these projects include operating at minimum operating pool (MOP) elevation, juvenile fish passage spill, and juvenile fish transportation. Adult fish passage facilities are operated nearly year-round, with a window for maintenance that varies at each project in the winter. Ice Harbor and Lower Monumental dams have adult fish ladders on both shorelines to pass adult fish upstream. Little Goose and Lower Granite dams have a single fish ladder on the south shoreline, with entrances that allow adult fish to enter the ladder along the entire span of the dam, reaching to the opposite end of the dam.

More detailed criteria and guidelines for lower Snake River project operations are addressed in the annual WMPs and the FPPs.

Reservoir Operations

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 (e.g., as needed to accommodate navigation at some projects when river flow is less than 50 kcfs) (Table 2-9). Additional caveats of when MOP restrictions may be altered at each project are outlined in Appendix E (FOP) of the FPP.

¹³ The Water Management Plans can be found at <http://pweb.crohms.org/tmt/documents/wmp/>.

¹⁴ The Fish Passage Plans can be found at <http://pweb.crohms.org/tmt/documents/fpp/>.

Table 2-9. Minimum operating pool (MOP) and normal operating elevation range for Snake River CRS projects

Project	Normal Operating Elevation Range (feet mean sea level)	1.5-foot MOP Restricted Elevation Range^a
Lower Granite ^b	733.0–738.0	733.0–734.5
Little Goose	633.0–638.0	633.0–634.5
Lower Monumental	537.0–540.0	537.0–538.5
Ice Harbor	437.0–440.0	437.0–438.5

^a MOP elevations are provided in feet above mean sea level (NGVD29).

^b Each pool may require variable pool operations during low flow as needed for navigation, as described in the Fish Operations Plan.

Turbines at the lower Snake River projects may be operated within and above the current 1% peak efficiency limit to increase flexibility for hydropower generation to meet demand. This action is a change from past operations when the hydropower turbines operated within 1% peak efficiency during the fish passage season. The operation is expected to occur primarily during high-flow periods, reducing high TDG and briefly during periods of unusually high power demand. For additional context in proposed turbine operation, refer to Section 2.3.3.

Juvenile Fish Passage Spill Operations

Juvenile salmon fish passage spill, including the operation of surface passage facilities such as spillway weirs, generally occurs at the lower Snake River projects from April 3 to August 31. However, these dates may shift through adaptive management based on new information related to fish run-timing or modified passage behavior, potentially due to climate change. Fish passage spill is modified annually in the Fish Operations Plan (FOP), which is included as Appendix E in the annual FPP. Operation of the spillway weirs is outlined in the FPP and coordinated in season through the FPOM coordination team.

Table 2-10 and associated bulleted details below represent the initial planned spring spill operation at the Snake River projects, which continues the operations originally implemented as part of the 2019 NOAA Fisheries CRS BiOp (NMFS 2019). Starting in 2021, these operations will initially apply an estimated 125% mean TDG spill cap (actual in-season spill caps will be recalculated daily, 16 hours per day) and performance standard spill (up to 8 hours per day). The 2021 operation would be refined, from the spring and summer spill operations applied during the 2019 NOAA Fisheries CRS BiOp, to include additional gas cap spill, lessons learned during operations in 2019, and would also include additional lessons learned during the operations in 2020. Starting in 2021, the spring spill operations would apply 125% TDG spill cap¹⁵ (actual in-season spill caps are reviewed daily and adjusted as needed) and performance standard spill operations at all four projects (“125 Flex”) (Table 2-10).

The implemented spill levels would be adapted based on the AIF (reference CRSO EIS) to account for unanticipated outcomes that affect the ability of the Action Agencies to maintain their individual federal mandates. Those modifications could include, but are not limited to, implementation of spill levels that

¹⁵ Pending the conclusion of the states of Oregon and Washington’s water quality standard processes.

are within the range of alternatives analyzed in the EIS (i.e., gas cap spill up to 125% TDG). Operations will be optimized at each of the four lower Snake River dams.

Table 2-10. Initial planned spring spill operation targets at the lower Snake River dams shown by project with 125% total dissolved gas cap (16 hours/day) and performance standard spill (8 hours/day)

Project	Flex Spill Operation (16 hours)	Performance Standard Spill (8 hours)
Lower Granite	125% total dissolved gas cap	20 kcfs
Little Goose	125% total dissolved gas cap	30%
Lower Monumental ^a	125% total dissolved gas cap	30 kcfs
Ice Harbor	125% total dissolved gas cap	30%

^a Action Agencies intend to continue to operate Lower Monumental Dam spring spill patterns in uniform spill under the flex spill operation and bulk spill during the performance standard spill or as described in the Fish Operations Plan (FOP).

For spill operations at the lower Snake River projects:

- Spring spill operations will be initiated on April 3 at lower Snake River projects and transition to summer spill operations on June 21.
- The 8 hours of performance standard spring spill may occur with some flexibility (except for Little Goose and Lower Granite operations described in the next key points). Performance standard spill at lower Snake River projects will occur in either a single 8-hour block or in 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 FPP. Performance standard spill shall not be implemented between 2200 and 0300 hours. No ponding above current MOP assumptions will occur, except as noted below.
 - 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% spill for 8 consecutive morning hours (April 3–15 starting at 0500 hours; April 16–June 20 starting at 0400 hours).
 - Little Goose Exception Two – After the operation in Little Goose Exception One has begun, during periods of involuntary spill, spill at 30% for 8 hours/day (April 3–15 starting at 0500 hours; April 16–June 20 starting at 0400 hours) 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 because of high inflows, water stored above MOP should be drafted out over the remaining hours by increasing spill to pass inflow from 1200–1600 hours (or 1300–1700 hours on April 3–15), then increasing spill as necessary from 1600–0400 hours (or 1700–0500 hours on April 3–15) to draft the pool back to MOP. If the drafting spill is forecasted to generate TDG levels in the tailrace greater than 130%, use all 16 hours to return the pool to MOP.

- 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 morning (beginning near dawn). Implementation of this modification may also trigger in-season reevaluation of options to balance power principle.
- Spill may be temporarily reduced at any project to assure navigation safety or transmission reliability.
- Summer spill operations will begin on June 21 and be implemented through August 31, unless otherwise determined via consultation with the Services through adaptive implementation of flex spill, including a late summer reduction in spill (August 15–31). These levels are detailed in Table 2-11.

As mentioned above, flex spill is focused on spring operations, but it is anticipated that during the summer spill period (from June 21 to August 31 on the lower Snake River), some reduction of summer spill levels in August may be required to offset the power system impacts caused by higher spring spill. Starting in 2021, these operations will initially apply the summer spill levels described in Table 2-11, including a late summer reduction in spill (August 15–31).

Table 2-11 details initial summer spill operations for this Proposed Action. These operations were originally evaluated in the 2019 NOAA Fisheries CRS BiOp (NMFS 2019).

Table 2-11. Initial summer spill operation targets at lower Snake River Dams

Project	Initial Summer Spill Operation: Volume/Percent of Total Flow Routed to Spillway (June 21–August 14) ^a	Late Summer Transition Spill Operation: Volume/Percent of Total Flow Routed to Spillway (August 15–August 31) ^a
Lower Granite	18 kcfs	RSW ^b or 7 kcfs
Little Goose	30%	ASW ^c or 7 kcfs
Lower Monumental	17 kcfs	RSW or 7 kcfs
Ice Harbor	30%	RSW or 8.5 kcfs

^a 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).

^b RSW = removable spillway weir.

^c ASW = adjustable spillway weir;

Juvenile Fish Transportation

The Corps will continue transporting juvenile Snake River salmon and steelhead during spring and summer migrations from the Snake River collector projects (Lower Granite, Little Goose, and Lower Monumental dams). Transportation operations will be carried out in accordance with all relevant FPP operating criteria.

The Action Agencies will continue to support NOAA Fisheries in preparing annual data summaries of juvenile fish survival, adult returns, current year in-river conditions, and water supply forecasts. These annual reports will be reviewed with the Regional Implementation Oversight Group. In addition, the

FPOM coordination team will review the results of transport studies annually and provide an annual recommendation to the Corps about how to operate the juvenile transport program. Achieving the “spread the risk” target for juvenile transport is no longer practical given the proposed spill operations, the operation of spillway weirs at collector projects, and the issue of debris loading on bypass system screens. The Corps will develop an annual plan for implementing the juvenile fish transportation program operations at the Snake River collector projects, taking into consideration the recommendations provided by regional sovereigns.¹⁶ Detailed descriptions of project and transport facility operations to implement the juvenile fish transportation program will be contained in an appendix of the FPP.

Juvenile Fish Transportation – Timing and Duration

The transportation of juvenile fish at Lower Granite, Little Goose, and Lower Monumental Dams will have a proposed transport start target date of April 24, but may begin as early as April 15 but no later than May 1, or as coordinated through the Regional Forum process (FPOM, TMT and/or RIOG if elevated). Fish collection will start one day before the transport start date, and the collected juvenile fish will be transported from each facility on a daily or every-other-day basis (depending on the number of fish) throughout the migration season. Transportation operations will be carried out at each project in accordance with all relevant FPP operating criteria. Spring transport will end with the completion of spring spill operations at lower Snake River collector projects (estimated date is June 20). The date summer juvenile fish transport resumes annually via truck and transport is still under discussion but is anticipated to occur between July 1 and August 15 and will continue until September 30 at Lower Monumental Dam and October 31 at Lower Granite and Little Goose dams.

Transportation operations may be adjusted because of research, conditions at fish collection facilities such as disease outbreaks (e.g., *Columnaris* disease), overcrowding, or temperature extremes, and coordinated through the FPOM coordination team, RIOG, and TMT, as appropriate under the Region Forum processes, to match juvenile outmigration timing or achieve/maintain juvenile fish survival. Although the date juvenile fish transport resumes is still under discussion, transport operations will continue until as late as September 30 at Lower Monumental Dam and on October 31 at Lower Granite and Little Goose dams in accordance with all relevant FPP operating criteria. Collected juvenile fish would be transported to a location below Bonneville Dam via barge in the spring or truck in the summer and fall on a daily or every-other-day schedule, depending on the numbers of fish collected at the collector projects. The start and end dates of transportation operations may be adaptively modified, if warranted.

Adult Fish Operations and Facilities

The Corps will continue to operate adult fishways and facilities to facilitate adult passage at each lower Snake River project, as necessary, and in accordance with the operating criteria outlined in the annual FPP. This includes fishway exit cooling pumps at Lower Granite and Little Goose dams. Generally, spill operations for juvenile fish passage and spill patterns have been developed to consider adult passage

¹⁶ *Sovereign* is used here to denote governments at federal, state, or tribal levels.

requirements at each project to minimize causing adult passage delays and minimizing fallback over the spillway.

LOWER COLUMBIA RIVER PROJECTS

The Action Agencies will operate the projects in the lower Columbia River (McNary, John Day, The Dalles, and Bonneville dams) in accordance with annual WMPs and FPPs (including all appendices). See Section 2.3.2.2 for operations to support ESA-listed chum salmon and non-listed fall Chinook salmon spawning and incubation in areas below Bonneville Dam.

Turbines at the Columbia River projects may be operated within and above the current 1% peak efficiency limit to increase the flexibility for hydropower generation to meet demand during high flow periods. This action is a change from past operations when the hydropower turbines operated within a 1% peak efficiency during the fish passage season (see Section 2.3.3). Under most conditions, it is best practice for the hydro generators to operate the turbines within 1% peak efficiency, yet there may be variable water conditions and/or power demand requirements when the hydropower system could be optimized with the proposed flexibility. An example of when turbines have been operated above 1% peak efficiency occurred in 2018 when high spring run-off flows resulted in involuntary spill above TDG standards, while all available turbines were operating within 1% peak efficiency. In order to reduce TDG levels, the turbines operated above 1% up to their generator limit. In this case, May 16 through May 25 operations at McNary Dam were allowed to operate outside of 1% peak efficiency if needed for power demand, which would result in a temporary reduction in TDG in the lower Columbia River. Turbines could also be run when plant capability would be limited due to generator outages. For additional context in turbine operation, refer to Section 2.3.3.

McNary, John Day, and Bonneville dams are equipped with JBSs. The Corps will operate JBSs at the lower Columbia River dams in accordance with the FPP. As project maintenance and/or construction schedules allow and while considering juvenile lamprey passage timing, the operation of a bypass system at one lower Columbia River project during March may be further coordinated by the FPOM team to gather updated information about juvenile fish migration timing.

Forebay elevations are routinely restricted for tribal Treaty fishing to a 2.0-foot operating range at John Day Dam and a 1.5-foot operating range at The Dalles and Bonneville Dams. These operations decrease debris, reduce entanglement of fishing nets, increase fishing boat access to the river, and help with net anchorage. Treaty fishing operations occur typically 2 to 5 days a week and can occur from April to September split into spring, summer, and fall Treaty Fishery periods.

More detailed criteria and guidelines for lower Columbia River dam operations are addressed in the annual WMPs and the FPPs.

McNary, The Dalles and Bonneville Reservoir Operations

McNary, The Dalles, and Bonneville dams will be operated within the normal forebay operating range for each project (Table 2-12).

Table 2-12. Normal Operating Elevation Range for Lower Columbia River CRS projects, excluding John Day Dam

Project	Normal Operating Elevation Range
McNary ^{a,b}	337.0–340.0
The Dalles ^b	155.0–160.0
Bonneville ^b	71.5–76.5

^a The authorized minimum operation elevation of McNary Reservoir is 335.0 feet; however, during low flow conditions on the Snake River (e.g., August, September and October), the pool elevation is typically operated between 337.0–340.0 feet to maintain navigation safety (minimum 13–14 foot depths).

^b McNary, The Dalles, and Bonneville Dams have no MOP or restriction and operate within normal operating elevation range shown.

John Day Reservoir Operations

The John Day reservoir is normally operated between 262.0 to 266.5 feet (except as needed for FRM purposes), with operating ranges adjusted seasonally to meet different management needs. The Action Agencies propose to increase the normal forebay operating range at John Day Dam to increase operational flexibility. During the juvenile fish passage season (April 10 – August 31) the John Day reservoir would be operated within two feet of minimum irrigation pool level (262.5 to 264.5 feet or “MIP [minimum irrigation pool] +2 ft”), except during the spring spill period (currently from April 10 to June 15), when the John Day forebay operating elevation window will be higher as described below.

From April 10 – June 1 (or as feasible based on river flows), the John Day reservoir elevation will be held between 264.5 feet and 266.5 feet (an average of 265.5 feet) to deter Caspian terns from nesting in the Blalock Islands Complex. 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 to 266.5 feet). The operation may be adaptively managed due to changing run timing; however, the intent of the operation is to begin returning to reservoir elevations of 262.5–264.5 feet on June 1, but no later than June 15, which generally captures 95% of the annual juvenile steelhead migration. The results of this action would be monitored and communicated with USFWS and NOAA Fisheries. During the operation, safety-related restrictions would continue, including but not be limited to maintaining ramp rates for minimizing project erosion and maintaining power grid reliability. Following this operation, the John Day reservoir elevation would return to MIP + 2 ft operation through August 31.

Outside the juvenile fish spill season (i.e., September 1 through April 9) the John Day reservoir may be operated to use the full normal operating range (262.0–266.5 feet), except as needed for FRM, irrigation, and other authorized purposes.

For all John Day reservoir operations, slight deviations from these levels, based on navigation needs, load following, and operation sensitivity may be required on occasion. These operations will be included in the annual WMP. Proposed John Day reservoir operations are summarized in Table 2-13 below.

Table 2-13. Proposed Seasonal John Day Reservoir Elevation Ranges (ft MSL)

Date	Minimum Pool ^a (ft)	Normal Range (ft)	Maximum Pool ^b (ft)	Primary Purpose(s)
Apr 10–Jun 1 ^c	262.5	264.5-266.5	266.5	Juvenile fish passage (prevent Caspian tern nesting at Blalock Islands Complex), irrigation
Jun 2–Jun 5 ^c	262.5	262.5-266.5	266.5	Transition to MIP ^d juvenile fish passage operation, irrigation
Jun 6–Aug 31	262.5	262.5-264.5	264.5	MIP ^d , juvenile fish passage, irrigation
Sep 1–Apr 9	262.0	262.5-266.5	266.5	Flood risk management, hydropower, irrigation

^a Permissible to draft to minimum pool elevation of 257.0 feet for flood risk management purposes. Flood risk management requirements may result in a draft below the lowest forebay elevation of 262.5 feet during MIP operations.

^b Reservoir may fill above stated maximum pool to elevation of 268.0 ft for flood risk management.

^c Start and end dates of the proposed spring avian predation disruption operation may be earlier than April 10 or extend later than June 1, but no later than June 15. Dates shown in the table reflect target dates and may be adaptively managed as prescribed in the annual Fish Operations Plan (FOP).

^d At John Day Dam, MIP is defined as a 2-foot forebay operating range to meet irrigation needs from 262.5 to 264.5 feet.

Spill Operations for Fish Passage

Juvenile salmonid fish passage spill in the lower Columbia River will occur at these projects from April 10 to August 31; however, these dates may shift through adaptive management based on new information related to fish run-timing or modified passage behavior, potentially due to climate change. Fish passage spill is laid out annually in the FOP, Appendix E, Annual Fish Passage Plan.

Table 2-14 and associated bulleted details present the planned spring spill operation at the lower Columbia River projects. This continues operations originally implemented as part of the 2019 NOAA Fisheries CRS BiOp (NMFS 2019), with refinements in additional gas cap spill, lessons learned from operations in 2019, and would include additional lessons learned during the 2020 operation. Starting in 2021, these operations will apply 125% TDG spill caps¹⁷ (actual in-season spill caps are reviewed daily and adjusted as needed) and performance standard spill operations at two projects (“125 Flex”): 120% TDG spill caps and performance standard spill (“120 Flex”) will be applied at John Day Dam, and 24-hour performance standard spill (40%) will be applied at The Dalles Dam.

The implemented spill levels would be adapted based on the AIF (reference CRSO EIS) to account for unanticipated outcomes that affect the ability of the Action Agencies to maintain their individual federal mandates. Those modifications could include, but are not limited to, implementation of spill levels that are within the range of alternatives analyzed in the EIS (i.e., gas cap spill up to 125% TDG). Operations at each of the four lower Columbia River dams will be optimized (Table 2-14).

¹⁷ Pending the conclusion of the states of Oregon and Washington’s water quality standard processes

Table 2-14. Initial planned spring spill operation at the lower Columbia River projects

Project	Flex Spill Operation (16 hours)	Performance Standard Spill (8 hours)
McNary (125 flex)	125% Total Dissolved Gas	48%
John Day (120 flex)	120% Total Dissolved Gas	32%
The Dalles (Performance Standard)	40% (no flex spill, performance standard spill 24 h/d)	40% (no flex spill, performance standard spill 24 h/d)
Bonneville (125 flex with 150 kcfs spill constraint)	125% Total Dissolved Gas	100 kcfs

- Spill may be temporarily reduced at any project, if necessary, to assure navigation safety or transmission reliability.
- Spring spill operations will be initiated on April 10 at lower Columbia River projects and transition to summer spill operations on June 16.
- 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 in 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 FPP unless otherwise revised under the Adaptive Implementation Framework process (Table BON-5 of FPP). Performance standard spill shall not be implemented between 2200 and 0300 hours.
- Spill for fish passage at Bonneville Dam capped at 150 kcfs due to spillway erosion concerns.
- Spill for fish passage at The Dalles Dam contained between the walls (Bays 1–8) unless river flows are over 350 kcfs, in which case spill outside the walls is permitted; TDG levels in The Dalles Dam tailrace may fluctuate up to 125% TDG before reducing spill at upstream projects, subject to the 40% spill cap.

As mentioned above, flexible spill is focused on spring operations, but it is anticipated that during the summer spill period (from June 16 to August 31 on the lower Columbia River), some reduction of summer spill levels in late August will be required to offset the power system impacts caused by higher spring spill. These levels are detailed in Table 2-15, including a late summer reduction in spill (August 15–31).

Table 2-15 details initial summer spill operations at the lower Columbia River projects that were originally evaluated in the 2019 NOAA Fisheries CRS BiOp (NMFS 2019).

Table 2-15. Initial planned summer spill operations at the lower Columbia River projects

Project	Initial Summer Spill Operation (kcfs or percent of total flow) June 16–August 14	Late Summer Transition Spill (kcfs or percent of total flow) August 15–August 31
McNary	57%	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	50 kcfs

Adult Fish Operations and Facilities

The Corps will continue to operate adult fishways and facilities and provide attraction spill to facilitate adult passage at each lower Columbia River project, as necessary, and in accordance with the operating criteria outlined in the annual FPP. Generally, spill operations for juvenile fish passage and spill patterns have been developed to account for adult passage requirements at each project to minimize adult passage delay, and account for adult fallback.

At Bonneville Dam, the second powerhouse Corner Collector will begin operation no later than April 10 and continue through the remainder of the spill season. To provide downstream passage for steelhead kelts, operation may begin as early as March 1 if criteria specified in the FPP are met. The first powerhouse ice and trash sluiceway will operate for adult fish passage outside of the spill season in accordance with the FPP.

Adult fish passage will be provided, and adult fish counted, in accordance with the FPP.

2.3.2.7 System-wide Operations

WATER MANAGEMENT PLAN

The Action Agencies will prepare a draft of the annual TMT WMP by October 1 each year, and a final plan by December 31. The WMP describes planned system operations for each water year (October through September), and seasonal updates are prepared as in-season data become available about the water conditions for the year. At a minimum, seasonal updates will be posted twice per year. The WMP will be developed in coordination with the Regional Forum (more information about the regional coordination can be found in Section 2.1), through the TMT. In the WMP, the Action Agencies will strive to achieve the best possible conditions, recognizing the plan's established priorities and the need to balance limited water and storage resources.

Within each water year, regional sovereigns can make operational requests through the TMT and Regional Forum to adjust planned water management, recognizing this may sometimes require trade-offs among priorities. The Action Agencies seek to meet these requests by optimizing the overall use of available volumes in storage reservoirs to benefit the juvenile and adult life stages of ESA-listed fish, as necessary, throughout the seasons, while considering resident fish needs and other reservoir objectives.

FISH PASSAGE PLAN

The Corps will prepare an annual FPP in coordination with Bonneville, NOAA Fisheries, and the Regional Forum working specifically with the FPOM coordination team. The Corps will operate its projects (including juvenile and adult fish passage facilities) year-round in accordance with the criteria in the FPP.

WATER QUALITY PLAN

The Action Agencies, in coordination with the TMT will periodically update the *Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers* (Water Quality Plan) and implement water quality measures to enhance ESA-listed juvenile and adult fish survival and mainstem spawning and rearing habitat, to the extent practicable.

ADAPTIVE MANAGEMENT

The Action Agencies will use targeted M&E, study results, and other new information to help inform coordinated adjustments of fish operations. That is, fish operations will be adaptively managed based on best available scientific information. Flexibility is critical for managing this complex multipurpose system while responding to uncertainty and natural variability. In coordination with NOAA Fisheries, USFWS, the Regional Forum, and other workgroups, the Action Agencies will continue to develop planning documents, including the WMP, the FPP, and the Water Quality Plan, to guide the implementation of system operations and planned maintenance activities in a manner that benefits ESA-listed species and other affected fish and wildlife. In-season and annual adjustments to the lower Snake and Columbia Rivers operations will be made thru established Regional Forum and processes. See Section 2.1, Regional Coordination, for a description of these Regional Forums and their respective roles and responsibilities.

IN-SEASON ADJUSTMENTS TO SYSTEM OPERATIONS

To adaptively manage the CRS, the Action Agencies may adjust planned system operations described in this proposed action for brief periods of time, depending on the circumstances, to accommodate varying runoff and other conditions as they arise at any of the 14 CRS projects. For unanticipated and unplanned conditions, the Action Agencies will respond as necessary to redress the condition, and when possible, will use the existing Regional Forum processes to adaptively manage and make necessary in-season adjustments in fish operations (e.g., juvenile fish transport and resident fish operations). Emergency operations will be managed in accordance with TMT protocols, the FPP, and other appropriate Action Agency emergency procedures. The Action Agencies will take all reasonable steps to limit the duration of any emergency changes in system operations that may adversely affect ESA-listed species. Where emergency changes to system operations cause significant adverse effects on ESA-listed species, the Action Agencies, will work thru established Regional Forums (e.g., FPOM, TMT, etc.) to stay apprised of adverse effects and potential operational changes, if feasible. In some instances, for example during extreme high flows, and coincident involuntary spill, operational changes may not be possible.

Dry-water-year Operations

A dry year is defined as a year when the Northwest River Forecast Center (NWRFC) May final forecast for April–August runoff at The Dalles Dam is below the 20th percentile for the NWRFC statistical period of record. The statistical 30-year period of record is currently 1981 to 2010,¹⁸ for which the 20th percentile value is 72.5 MAF. Consistent with prior recommendations from NOAA, the Action Agencies propose the following system management actions, where practicable, to benefit migrating salmon and steelhead in dry water years:

- Within the defined draft limits for flow augmentation (i.e., the reservoir elevations described for storage projects above), flexibility will be exercised in a dry water year to distribute available water across the expected migration season to optimize biological benefits and anadromous fish survival. The Action Agencies will coordinate use of this flexibility with the Regional Forum through the TMT.
- In dry water years, operating plans developed under the Columbia River Treaty may result in Treaty reservoirs being operated below their normal refill levels in the late spring and summer, thereby increasing flows during that period relative to a standard refill operation. It should be noted that the Columbia River Treaty FRM terms expire in 2024.
- The U.S. Entity will continue to seek annual storage agreements between the U.S. and Canadian entities to identify flow augmentation objectives from Treaty storage in Canada and will seek to include provisions that allow flexibility for the release of any stored water to provide U.S. fisheries benefits in dry water years, to the extent possible.
- As noted above, the Non-Treaty Storage Agreement is in place for an additional 0.5 MAF of non-Treaty storage for use in dry water years (but not in consecutive years).
- Bonneville will implement, as appropriate, measures recommended in the *Guide to Tools and Principles for a Dry Year Strategy* (Bonneville 2016) to reduce the effect that energy requirements may have on ESA-listed species.
- Transport operations will be adaptively managed in dry years for low flow conditions and coordinated using the Regional Forum process.

2.3.3 Operations for Power System Management

Under the Proposed Action, the Corps and Reclamation (the operators of the CRS dams) will continue to operate the dams to generate electricity, among other authorized project purposes. The 14 CRS hydropower facilities supply more than one-third of the region’s electrical power. The Corps and Reclamation coordinate CRS management with Bonneville, which markets and transmits the electricity the CRS dams generate, along with other power resources that collectively form the 31-project Federal Columbia River Power System.

¹⁸ The official 30-year statistical values will be updated by the NWRFC in 2020.

For many decades, the CRS has provided the Pacific Northwest with a substantial amount of cost-effective, carbon-free, renewable power. Total electricity used in the Pacific Northwest has half the carbon intensity of the rest of the United States due in large part to hydroelectric power generation (PNUCC 2014). In high-water years, carbon dioxide (CO₂) emissions tend to be even lower than normal because additional hydropower reduces the need to operate gas and coal power plants. However, even in a dry water year, the CRS alone produces about 7,000 average megawatts of hydroelectricity, enabling the region to sustain a relatively small carbon footprint. CRS hydroelectric efficiency improvements achieved to date avoid between 1.7 and 2.7 million tons per year of CO₂ emissions, and annual variances are based on the amount of water available for hydropower generation. Additional efficiency improvements planned through 2030 are estimated to achieve CO₂ reductions between 0.4 and 0.7 million tons per year (NPCC 2015). The CRS is also a crucial part of integrating and backing up intermittent, renewable energy resources on the electric grid. Bonneville has connected an estimated 5,200 MW of renewable energy to its transmission system—enough to power a city three times the size of Seattle. The CRS is contracted to balance a subset of these wind (approximately 2,764 MW) and solar (estimated 5 MW) resources as part of Bonneville’s balancing authority; however, dynamic reserve products sold by Bonneville may balance wind energy that is part of multiple balancing authorities (e.g., Independent Wind Generations have elected to be part of other balancing authorities). Bonneville expects another 3,000 to 4,000 MW of renewable energy to be incorporated on its system by 2025, setting Pacific Northwest states well on their way to achieving long-term renewable energy targets.

2.3.3.1 Power Generation

As noted previously, the 14 CRS projects can be classified as either run-of-river or storage projects. This distinction is important for power generation, because run-of-river projects generate electricity based on inflows and have minimal ability to shape flows. Thus, at run-of-river projects (e.g., lower Snake River dams) there is minimal ability to control the timing of electricity generation; some generation can be adjusted from one hour to the next, and perhaps to the subsequent day. In contrast, storage projects may store the water until there is a need to generate electricity. Storage projects may store inflows for a week, a month, or even another season, depending on available storage capacity and overall system flexibility, given other constraints such as FRM and operations for fish. When deciding on water releases from storage projects, the Action Agencies consider electricity generation capability at downstream run-of-river projects, among many factors.

The amount of electricity generated at the CRS projects depends on a variety of factors, including operational constraints, ESA responsibilities, regional load,¹⁹ and river flows. Seasonally, river flow determines when power is generated (i.e., peak hydroelectric generation typically coincides with spring runoff, while low flows and low generation generally occur in late summer and fall). For system operations, the Action Agencies generally prioritize FRM, minimum generation to support the transmission system (see Appendix B for more detail) and environmental responsibilities, such as conservation actions for protected fish species, before using any remaining flexibility to manage water

¹⁹ Load refers to electricity that is being consumed in the region. It is also known as demand.

flow for power generation to meet the daily and seasonal demand for electricity at storage projects (e.g., Grand Coulee Dam).

In managing the system to address or avoid emergencies, CRS operations are prioritized to protect human health and safety, as well as the safety and reliability of the electricity grid. Energy supply (including generation, imports, and exports) must equal load (demand for electricity) at all times. Bonneville participates in the wholesale electricity market to buy and sell electricity to assure that electricity demand and supply on the federal system are always balanced. Peak hydroelectric generation tends to occur during daytime hours to meet peak power demand, if not constrained by other requirements.²⁰

There are seasonal peaks of energy demand, as well. In the Pacific Northwest, energy demands have typically peaked in the wintertime as the need for heating increases. Ensuring a sufficient supply of electricity in the winter can be a challenge, particularly during extreme cold spells, when demand increases dramatically region-wide and little or no electricity is available in the wholesale market. More recently, with higher regional temperatures, summer demands for energy have also been increasing over historical trends as demand for air conditioning increases. The demands for regulating and balancing power generation from the projects from which Bonneville markets power increased dramatically with the restructuring of electricity markets in the mid-1990s and the renewable resource boom in the Pacific Northwest that started in the mid-2000s.

Because most renewable resources generate 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, Bonneville 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. An example of how wind and solar power resources are integrated into the CRS includes 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 during nighttime hours, most commonly implemented between 2300 and 0500 hours when demand for power is lowest and 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

²⁰ For example, Bonneville Dam generates more power at night during the late fall and early winter months because of the requirement for relatively low flows during daylight hours below the dam to encourage daytime chum spawning at elevations that will not be dewatered later in the winter.

periods. The timing and need for ceasing power generation during this period of time is difficult to predict. However, based on previous operations between December 15 and February 28 and during nighttime hours only, Bonneville estimates the use of this operation may occur one out of every 3 to 5 days at each project. See the WMP²¹ for additional details.

2.3.3.2 Operating Reserves

As a North American Electric Reliability Corporation (NERC)-registered balancing authority, Bonneville is responsible for maintaining the balance between generation and load within the Bonneville balancing authority area.²² Figure 2-23 shows the area for which Bonneville is a balancing authority. In this area, Bonneville manages and provides operating reserves based on a required reserve obligation using dispatchable energy generation.²³ This ensures generation within the balancing authority area always matches load. The most common dispatchable power plants for reserve obligations in the Northwest are hydropower and natural gas.

Hydropower is dispatchable as long as there is flexibility to increase or decrease generation. This often means having the ability to increase or decrease flows coming from an upstream project. The CRS projects cannot all operate simultaneously at full capability to reserve some dispatchable generation to increase generation, as needed. At certain times, Bonneville's obligation to balance power generation to match load within the balancing authority area, including maintaining operating reserves, may take priority over other water management functions in coordinating CRS operations. This is mostly likely to occur during extreme low and high flow conditions.

There is little capacity to hold reserves at the lower Snake River dams when the forebays are maintained within a narrow operating range at MOP. This restriction in operating range constrains reservoir storage capability and, therefore, limits the ability to hold many reserves. Accordingly, Bonneville sets aside a certain portion of hydropower generation capability to meet its reserves obligation for unexpected increases or decreases in generation or load in the Bonneville balancing authority area. These unexpected changes in generation can come from variable energy generation like wind, sudden generation outages, or transmission constraints. These events are rare and when they occur, the Action Agencies may be able to cover the contingencies without temporarily reducing spill. However, the use of contingency reserves during spring and summer spill may temporarily require that a portion of spilled water be replaced with turbine flow during a qualified event when the transmissions system is in an

²¹ Water Management Plan (<http://pweb.crohms.org/tmt/documents/wmp/2020/>)

²² A balancing authority is the responsible entity that schedules generation on transmission paths ahead of time, maintains load-interchange-generation balance within a balancing authority area, and supports interconnection frequency in real time. The balancing authority area is the collection of generation, transmission, and loads within the metered boundaries of the designated balancing authority. The balancing authority maintains load-resource balance within this area.

²³ 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 plants 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.

unexpected poor state (e.g., transmission interruption or a failed generator). The exchange of spill for generation would be limited in duration while other options to respond to the event are being negotiated. The expected impact on spill reductions is typically once per month for less than an hour.

To assure grid reliability, especially during unexpected changes in water flows on the Snake River where limited forebay space is available, Bonneville will carry reserves on turbines during spring spill operations at the four lower Snake River and four lower Columbia River dams. Turbines may operate above 1% peak efficiency for hydropower generation flexibility with increased likelihood, but not exclusively, during high flow periods. The operation is expected to occur primarily when there is insufficient turbine capacity to generate with the available water after providing fish passage spill. This condition occurs most frequently in high flow periods, a time when operating above 1% would also help manage for high TDG. This operation may also occur to maintain power system reliability if contingency reserves are deployed or for limited durations during periods of high power demand. This operation is expected to occur infrequently as the Action Agencies strive to operate turbine units in the most efficient manner possible (i.e. within the 1% efficiency band) because it is typically the best operation for power.

The available use of this operation for power allows Bonneville to carry contingency reserves in the upper generation band with a benefit at all hours. Contingency reserves will be carried and implemented to meet energy demands that are caused by unexpected interruptions or failure of a generator. The timing and need for contingency reserves and when turbines will be operated above 1% peak efficiency is difficult to predict; however, Bonneville estimates that it would likely operate the turbines above 1 percent roughly once per month during the deployment of contingency reserves, averaging about 35 minutes per event. Operating above 1% when there is insufficient turbine capacity, primarily but not exclusively in high-flow periods, might occur for extended periods in about 20% of the 80 years modeled at McNary Dam and 5-10% of the years at the other projects. Recent studies showed that turbine operations above 1% can provide similar turbine survival for juveniles at some projects, for example, Bonneville Powerhouse 1.

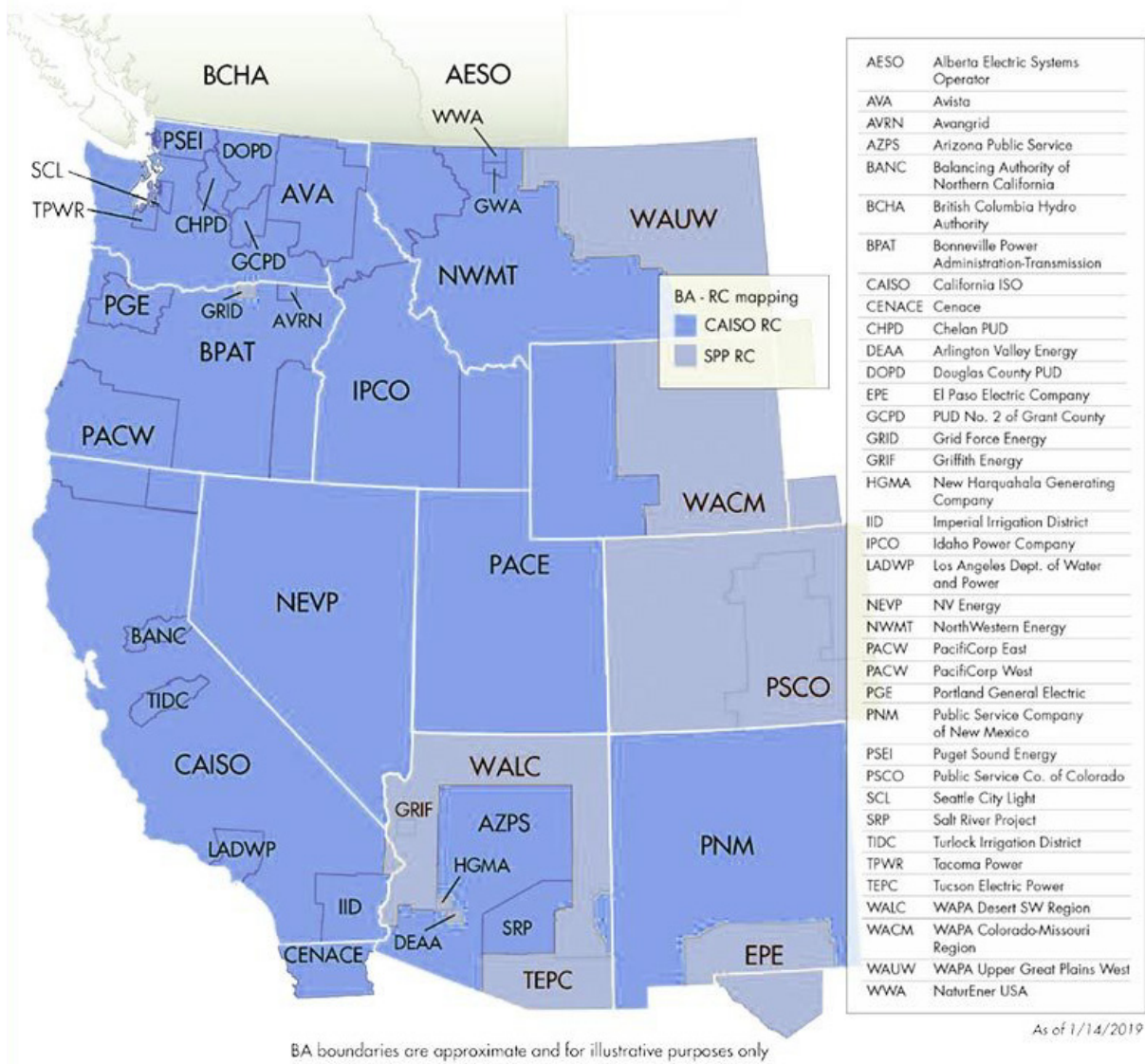


Figure 2-23. West Coast balancing authorities (or control areas)

2.3.3.3 Transmission

Bonneville, as the NERC-registered transmission operator, is also responsible for maintaining the safety and reliability of the transmission grid. The Proposed Action includes water management actions taken at the dams to increase or decrease hydropower generation in response to needs on the interconnected transmission system, for example to address transmission reliability needs. (See Appendix B for more details.)

2.3.3.4 Cessation of Fish Screens at Ice Harbor, McNary, and John Day Projects

Pending installation of improved fish passage (IFP) turbines at Ice Harbor, McNary, and John Day projects, and coordination with the Services, biological studies will be conducted by the Action Agencies to determine direct fish passage survival through the IFP turbines. If the study results demonstrate a

neutral or beneficial effect on ESA-listed fish survival metrics for each dam (see Section 2.7.2.5) and aid in the migration of juvenile lamprey, the Action Agencies will consider cessation of turbine intake bypass screen installation (and other screens, if appropriate) at these projects to increase the efficiency of turbine power generation.

During the expected timeframe of this consultation, the IFP turbines will be installed at 3 out of 6 turbine units at Ice Harbor Dam and tested for direct fish passage survival. Results will determine if screen removal is possible at this location. 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, initiation of the design phase has begun and the likelihood of completion during this consultation is uncertain. Advancement of these screen removal projects is dependent on future investigative studies (see Section 2.7.2.5 for details regarding studies related to fish screens).

2.3.4 Operations for Navigation

The Corps operates the eight CRS projects in the lower Columbia and lower Snake Rivers to provide for navigation. Navigation locks at the dams allow passage of boats and barges to transport products from the Pacific Ocean to inland ports as far upstream as Lewiston, Idaho. The 465-mile Columbia-Snake Inland Waterway represents a key link to national and international markets for the Columbia-Snake River Basin interior region. It facilitates barge transport of commodities between the Pacific Ocean and Lewiston, Idaho, the farthest inland port. This transportation system consists of the Federal Navigation Channel, locks at mainstem dams, port facilities, and shipping operations.

The CRS supports international trade of an estimated value of over \$20 billion annually and carries about 56.9 million tons of cargo, making it the second largest export gateway on the West Coast. The average annual (2010–2014) tonnage passing through navigation locks at The Dalles and Ice Harbor dams was 7,719,748 and 3,475,104 tons, respectively. This equates to approximately six commercial vessels per day at lower Columbia River dams and three vessels per day at lower Snake River dams.

This Proposed Action includes the operation of the eight CRS run-of-river projects for navigation, including 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 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 operating above MOP. These adjustments may sometimes be necessary during the spring or summer fish passage season and possibly during periods of low or high flows. Other federal activities associated with navigation not related to operations (e.g., dredging) are covered under completed consultations (NMFS 2012c, 2014a, b) and are not covered here.

Navigation locks were designed to allow 15 feet of depth over the concrete sills on the upstream and downstream entrances to the locks. This depth is provided at the upstream entrances of the locks within normal operating ranges (between maximum and minimum operating pool) for the reservoirs. The depth over downstream entrance sills, however, can be affected by reduced operating pool elevations

on the lower Snake River and by low river flows (approximately 50,000 cfs or less).²⁴ If this happens, reservoir elevations may be raised to provide safe clearance for vessels entering and leaving the navigation locks.

2.3.5 Operations for Irrigation and Water Supply

The Corps and Reclamation operate CRS projects for the purpose of supplying federal and non-federal irrigation water, among other purposes. The Proposed Action includes water withdrawals from the mainstem Columbia River to supply water to the Columbia Basin [irrigation] Project. Grand Coulee Dam is integral to CRS operations and is also the primary storage and diversion structure for water supplying the Columbia Basin Project, a major Reclamation irrigation project on the upper Columbia River in central Washington. In addition to Grand Coulee Dam and its impoundment (Lake Roosevelt), the major facilities of the Columbia Basin Project included in this consultation are the Grand Coulee Powerplant complex, Banks Lake (an off-stream reservoir), and John W. Keys III (JWKIII) pump/generating plant (which pumps water from Lake Roosevelt behind Grand Coulee Dam to Banks Lake). In this Proposed Action, Reclamation is consulting on diversion of Columbia River water to Banks Lake. The majority of this water is diverted through the JWKIII. More detail about the operations of the JWKIII and Banks Lake and the timing and location of the diversion can be found in appendices A and C. In addition to the consultation on the Columbia River System management and impacts on aquatic listed species, Reclamation is engaging in a separate consultation with USFWS related to the Columbia Basin Project irrigation distribution system. The CBP distribution system starts at Dry Falls Dam, an outlet works on Banks Lake.

Additionally, as a matter of convenience, Reclamation is consulting on the mainstem Columbia River hydrologic effects of six other Reclamation irrigation projects that are not coordinated with the CRS. The flow effects on the mainstem Columbia River for Reclamation's irrigation projects (The Dalles Project, Chief Joseph Dam Project, Umatilla, Yakima, Deschutes, and the Crooked River Projects) are included in this consultation. Depletions and effects of these depletions from these non-CRS irrigation projects are encompassed in the Columbia River hydrologic models for the CRS. The effects of operation and maintenance to a tributary from irrigation projects in that tributary are or will be addressed under separate ongoing or completed consultations. Reclamation describes the timing and cumulative volume of these non-CRS irrigation project depletions in Appendix C.

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

²⁴ Over the last two decades, the Action Agencies have operated the lower Snake River projects at minimum operating pool (MOP) as a management tool during the fish passage season. As noted above, for operations beginning in 2019, the maximum range of effective operating pool elevations is currently being reevaluated for meeting all authorized project purposes.

installation and operation of pumping stations. More detail about Corps irrigation operations along the lower Columbia and lower Snake Rivers can be found in Appendix A.

2.3.6 Operations for Recreation

The reservoirs and project lands provide recreational opportunities for boaters, anglers, swimmers, hunters, hikers, and campers throughout the year. The Action Agencies take into consideration recreational values when defining CRS management. In general, the storage and run-of-river projects are operated within normal operating limits, in part to provide for recreational opportunities at these projects. Numerous recreation sites, access sites, state parks, and boat launches are associated with the Corps' and Reclamation's project lands throughout the CRS. Nearly all sites provide recreation opportunities that either depend on water or are enhanced by the proximity of water.

In this Proposed Action, the Action Agencies are consulting on the operation of the CRS to support recreational activities. This includes managing reservoir elevation and river flows. Both recurring and one-time requests for special operations to support recreation are considered, within normal operating limits and other project requirements, such as FRM and fish conservation operations. Any other federal activities associated with recreation are not included in the scope of this Proposed Action.

2.3.6.1 Libby Dam

Designated facilities provide water-based and land-based recreational opportunities. The Corps, the U.S. Forest Service (USFS), and private enterprises operate a mix of recreational facilities associated with the reservoir and river. The range of usability for reservoir boat ramps is from full pool to approximately elevation 2,300 feet.

2.3.6.2 Hungry Horse Dam

Hungry Horse Dam is authorized for recreation, but Reclamation does not operate specifically for this purpose at Hungry Horse Dam.

2.3.6.3 Albeni Falls Dam

At Lake Pend Oreille, boat launching ramps, swim beaches, marinas, and other facilities have been developed to support recreational activities. Generally, from June through mid-September, the summer lake elevation is generally held between 2,062.0 and 2,062.5 feet for recreation. The exact date to reach the summer operating range is determined in season depending on FRM concerns. Generally, from June through Labor Day, the Corps decides when the lake will reach the summer operating range, depending on FRM concerns. The lake may be held within the summer operating range for recreation after Labor Day, but the September operating range is from 2,060 to 2,062.5 feet.

2.3.6.4 Grand Coulee Dam

Lake Roosevelt is typically filled after the Fourth of July holiday. The desired operation is to have Lake Roosevelt 3 to 4 feet below full pool going into the holiday to provide beaches for recreation. The

shorelands of the Lake Roosevelt National Recreation Area, managed by the National Park Service, consist primarily of a narrow band of land above the maximum high-water elevation (1,290 feet). In most cases, the minimum amount is determined by the elevation 1,310-foot contour, while the maximum ranges up to almost a half mile from the high-water line in a few locations.

2.3.6.5 Lower Snake and Columbia Rivers

Waterfowl hunting operations are provided Wednesdays, weekends, and holidays from mid-September through January at McNary, Ice Harbor, and Little Goose dams. The pools are operated in the upper end of their operating range in part to provide better access for hunters. In addition, there are annual operation requests for McNary and Bonneville dams to support recreation (e.g., hydroplane boat races and wind surfing competitions). These requests fall within the authorized operating range of these projects.

2.3.7 Operations for Water Quality

The Action Agencies manage the CRS to maintain water quality, to the extent feasible, by managing releases of water to avoid excessive TDG and to meet downstream flow and temperature objectives. These operations include system spill coordination, refill reliability at storage projects with temperature operations, and use of Selective Withdrawal Structures at appropriate projects. A TDG Management Plan is included as an appendix to the annual WMP. The TDG Management Plan describes fish passage spill and involuntary spill, use of the Spill Priority List, the process for setting spill caps, TDG management policies, and the TDG monitoring program.

2.3.8 Operational Emergencies

In emergency situations the co-lead agencies operate the 14 CRS dams in accordance with the WMP Emergency Protocol, contained in an appendix in the WMP. The Emergency Protocol outlines notification, consultation, and documentation requirements for coordination with the TMT, including NOAA Fisheries, USFWS, and sovereigns if CRS operations must vary from normal to respond to an emergency. An emergency may be related to hydropower generation, transmission loss or interruption, fish emergencies related to equipment failure or other interruption of fish protection measures, and other unexpected circumstances such as fires, human health and safety concerns, or threats to dam infrastructure. If an emergency action is anticipated, the co-lead agencies would convene a meeting of TMT to discuss the threat and proposed preemptive actions to avert or minimize effects. If preemptive actions fail to resolve the situation, prioritized emergency actions would be implemented and communicated to the TMT and documented for reporting and after-action review. All reasonable steps are taken to limit the duration of any emergency and to offset adverse effects of emergency actions in place or in kind.

2.4 SYSTEM MAINTENANCE

This section describes preventive and corrective maintenance that is coordinated and planned to occur at regular intervals or expected to occur (at some unknown time) within the timeframe of this consultation. Such maintenance concerns fish facilities, spillway equipment, navigation locks, generating

units, and supporting systems. Maintenance is conducted to assure project reliability, safety, and compliance with regulatory requirements. Schedules for certain maintenance may necessitate planning for 2 to 3 years in advance.

Maintenance that is not planned in advance 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 be taken offline to fix. All maintenance activities will comply with all applicable state and federal permits, best management practices and design procedures, to avoid and minimize potential impacts to listed species and their critical habitats. Examples of design criteria intended to minimize potential impacts to listed species are found in existing ESA consultations such as the Standard Local Operating Procedures for Endangered Species (SLOPES) biological opinions that NMFS prepared to address general construction impacts from transportation (NMFS 2012a), over-water structures (NMFS 2012b), and even restoration actions (NMFS 2013). Examples relevant to this consultation include ensuring that hazardous materials will be stored, and equipment maintained on existing paved areas or away from an open, natural water body to the maximum extent practicable. Erosion controls will be in-place (prior to construction) to prevent erosion and discharge from the project site. Measures may include, but are not limited to silt fences, oil absorbing floating booms, and spill containment supplies. Activities will be timed to occur during in-water work windows, and in the dry, from existing roads, pathways, etc. as feasible. Listed species will be removed / salvaged, and prevented from re-entering the area, until construction ceases, as practicable. Following construction, disturbed natural areas will be restored via re-vegetation, invasive and non-native species control, etc. Finally, actions will be monitored and respectively reported per state and federal regulatory permits. The AAs anticipate two to three unscheduled maintenance activities per year across all projects, with each action lasting two to twelve weeks. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of a project. These events will be coordinated through the appropriate teams, such as the FPOM coordination team and TMT, under the Regional Forum 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. Examples of non-routine maintenance include power plant modernization and major rehabilitations of hydropower turbines and generators. Additionally, work conducted on transmission equipment can take a powerhouse transmission line out of service thereby affecting unit operations.

2.4.1 Libby Dam

Five generating units at Libby Dam discharge into the Kootenai River. The units have an estimated discharge capacity estimate of up to 5,200 cfs each. These capacities can vary somewhat, depending on forebay and tailwater elevations (net head). The total hydraulic capacity of the project is determined by how many generators are online and their operating load. Flows dictate generator operations; generators are scheduled to operate, except during periods of reduced flow, when units may be scheduled for annual maintenance and capital improvements.

2.4.1.1 Scheduled Maintenance

Scheduled maintenance activities are planned for the periods when the flow is at less than full powerhouse capacity. Each of the five generating units requires a 30-day outage each year for preventive maintenance. Only one ladder will be out of service or operating out of standard operating criteria at any one time, unless specifically coordinated thru FPOM. Units are taken offline one at a time, and the draft tubes are partially dewatered for internal access. At no time are fish handled during the dewatering process, because the draft tubes are almost never fully drained. Activities conducted during scheduled outages include cavitation repair; preventive maintenance; and calibration of generator controls, system protective devices, and auxiliary systems to assure that they are operating properly to maintain the reliability of the bulk power system. In addition, components and devices are inspected for signs of abnormal wear and consideration for future outage work. At the conclusion of the outage, the draft tube stop-logs are removed, which allows fish access to the tailrace. Longer outages may be required for certain capital improvement projects. If an outage becomes prolonged (more than a few days), fish may be removed from the dewatered draft tube by hand (in coolers) and released into the river.

2.4.1.2 Operational Constraints

Several constraints throughout the year affect maintenance scheduling at Libby Dam:

- There are two primary work windows: winter (January 1 to April 15) and summer (July 15 to November 15). These work windows are driven by the river flow levels required for listed species and FRM.
- The periods when full powerhouse capacity may be required are late fall (November 15 to January 1) and spring (April 15 to July 15). During these times, there will be extended periods of full flow, and no maintenance outages can be scheduled.
- Depending on the spring weather and runoff peaks, spillway discharges may be required to help control forebay elevations.
- During the spring freshet, all units are required to be available for FRM and to support the BiOp for sturgeon flow augmentation operations during May and June.
- The minimum required flows for bull trout (6,000–9,000 cfs) are in effect at Libby Dam from May 15 through September 30. Routine maintenance activities do not interfere with the ability to provide minimum bull trout flows, which can be achieved with two units in operation. The summer work period is determined by the end of sturgeon flow augmentation, along with achievement of forebay FRM elevation.
- Typically, Libby Dam operates at less than full powerhouse capacity during the summer period. All work is scheduled and completed before commencement of FRM draft operations (typically November and December).

2.4.1.3 Non-routine Maintenance

Turbine unit overhaul. It is likely that the five power generation units at Libby Dam will be taken out of service for significant maintenance within the next 10 years. One unit at a time will be taken out of service for 6–9 months, potentially starting between 2020 and 2024. To the maximum extent practicable, unit outages will avoid disrupting sturgeon pulse flows (May–June). Each outage will consist of a unit rewind and potential other upgrades, as necessary.

2.4.2 Hungry Horse Dam

2.4.2.1 Power Plant Maintenance

At Hungry Horse Dam, there are four generating units that discharge flow to the South Fork Flathead River. Each generator has a hydraulic capacity of around 3,000 cfs (when the reservoir is at full pool, 3,560 feet); therefore, the total hydraulic capacity of the project is around 12,000 cfs if all units are online and there are no transmission restrictions. Transmission restrictions limit total generation from the power plant. The current generation limit is 310 MW of the total plant capacity of 428MW which equates to a flow of around 9,000 cfs. The hydraulic capacity of the power project at any given time during the year is directly affected by the reservoir elevation, transmission limitation, and how many units are offline for maintenance. Generator maintenance is characterized as either scheduled or unscheduled, the latter being an unplanned or forced outage.

2.4.2.2 Scheduled Maintenance

Reclamation must perform routine maintenance at regular intervals on all units to comply with NERC/Western Electricity Coordinating Council (WECC) regulatory requirements; Reclamation facilities instructions, standards, and techniques requirements; and to assure project reliability. Numerous constraints throughout the year affect maintenance scheduling at Hungry Horse Dam. With peak discharge occurring in the spring, routine maintenance is limited, to the extent possible, to minimize the number of units that must be worked on so that as much water as possible can be passed through the turbines and not spilled. Discharges greater than project capacity are typically spilled through the hollow jet valves, which can result in elevated TDG production in the South Fork Flathead River. Empirical data and estimates show that limiting spill to a maximum of 15 percent of total outflow will help avoid exceeding the Montana State TDG standard of 110 percent saturation. TDG is continuously monitored during the spring and summer in the South Fork Flathead River at a gaging station located about 2 miles downstream from the dam. The TDG sensors are removed during the late fall and winter to prevent damage caused by freezing.

In addition to TDG production, water temperatures in the South Fork Flathead River are a consideration when scheduling generator maintenance. Hungry Horse Dam has a selective withdrawal system for the project intakes. Water that is spilled through the hollow jet valves is much colder than that which can be released through the project via the selective withdrawal system. To a certain extent, the selective withdrawal can be adjusted on the remaining online units to offset any colder water released through the hollow jet valves but maintaining the correct temperature in the South Fork Flathead River may be problematic if spill is high and more than one generator is offline for maintenance.

2.4.2.3 Selective Withdrawal System Maintenance

Inspections and scheduled maintenance of the selective withdrawal system occur when the system is not in service (November–May), to prevent affecting temperature control operations during the in-service season. Because the selective withdrawal system operates independently for each of the four power plant penstocks, any corrective maintenance that needs to occur during the in-service season typically has minimal impact on the ability to control discharge temperatures. Discharges can be switched to another or a combination of other generating units to conduct repairs on selective withdrawal gates without affecting temperature control operations. However, if required discharges are greater than what can be passed through the available units, some amount of temperature control may be compromised. Selective withdrawal maintenance at Hungry Horse is planned for a minimum of one out of three years. This maintenance typically takes advantage of FRM draft and takes 2 to 3 weeks.

2.4.2.4 Unscheduled and Non-routine Maintenance

In any given year, additional outages can occur because of NERC/WECC requirements or unexpected events/equipment failures, which may limit the ability to pass water through the powerplant and in some cases may result in additional spill.

Reclamation is planning a Hungry Horse Powerplant Modernization and Overhaul Project (Reclamation 2018) in the next 10 years. This overhaul would take place over four years, currently scheduled to start around 2020 or 2021. During one of the four years maintenance would require outages for one year in the powerplant, limiting the power plant to two units available for one year, reducing the hydraulic capacity to approximately 6 kcfs. This could result in additional spill in this one year, and the maximum TDG anticipated from the overhaul study was 120%. In most years the reduced hydraulic capacity would not result in significantly more spill and would not result in higher TDG percentages than presented in this analysis. Because spill typically occurs during the spring when it is cold, it takes a substantial increase in spill to raise TDG above 115%, often during this period the resident fish have migrated out of the south fork at that time of year, and elevated TDG is diluted when flowing into the mainstem Flathead River.

2.4.3 Albeni Falls Dam

2.4.3.1 Power Plant Maintenance

All generators are available for use throughout the year, except during the fall months, when units are taken out of service, one at a time, to perform routine or annual maintenance.

2.4.3.2 Scheduled Maintenance

Every year, each of the generating units is out of service for at least a 2-week period (typically 2–3 weeks) for annual inspection and maintenance. Each unit is dewatered every 6 years to allow inspection of the turbine, scroll case, and draft tube area; the outage for this maintenance is at least 3 weeks long (typically 3–4 weeks). During the outage, preventive maintenance and calibration are performed on all

generator controls, auxiliary systems, and protective devices to assure that they are operating properly and are not exhibiting any abnormal wear.

Several constraints throughout the year affect maintenance scheduling at the Albeni Falls project. Albeni Falls Dam regulates the elevation of Pend Oreille Lake upstream of the project and must adhere to a WCM for elevations and flow changes. To the maximum extent possible, water is passed through the three generating units and not spilled. Therefore, best attempts are made during the fall drawdown and the spring runoff to assure that all three generating units are available when sufficient head is available for generation. Required discharges greater than project capacity are passed over the spillway.

2.4.4 Grand Coulee Dam

2.4.4.1 Routine Maintenance

With peak discharge occurring in the spring, routine maintenance is limited, to the extent possible, to minimize the number of units that must be worked on so that as much water as possible can be passed through the turbines. Routine maintenance does not affect flow, but increased spill could periodically result in elevated TDG saturations above the Washington State water quality maximum standards.

2.4.4.2 Drum Gate Maintenance

Reclamation's Operations and Maintenance Program requires annual inspections and dam safety maintenance for the eleven 135-foot-long, 30-foot-high drum gates. Inspection and maintenance activities can only occur when Lake Roosevelt is at or below elevation 1,255 feet for at least 8 weeks. Drum gate maintenance is planned to occur annually during a period between March and May, to coincide with the FRM drawdown of the lake. However, during dry years, FRM operations will not draft Lake Roosevelt low enough for a long enough period of time to perform necessary maintenance on the drum gates. During extended droughts or even in normal water years, when FRM operations do not require the reservoir to draft below elevation 1,255 feet for at least 8 weeks, a forced draft may be required to perform maintenance. A forced draft can reduce the chance of reaching the April 10 elevation objective and reduce downstream flows during refilling, which could have negative impacts on ESA-listed species. For this reason, Reclamation agreed to criteria (Table 2-16) that would reduce the risk to ESA-listed salmon in dry years, by allowing deferral of maintenance in some dry years, to the extent possible.

- Drum gate maintenance may be deferred in some dry water years, but drum gate maintenance must be completed a minimum of one time in a 3-year period, two times in a 5-year period, or three times in a 7-year period.
- To reduce the likelihood of having a forced draft occur in a dry year, in-season criteria were developed to guide operations in normal and wet years to accomplish drum gate maintenance. The in-season criteria are based on the FRM requirement for the April 30 maximum Grand Coulee Reservoir elevation, as determined by the final February forecast of the April–August water supply. The February forecast is used to allow sufficient time to draft the reservoir below 1,255 feet by March 15. These criteria are summarized in Appendix A and described in greater detail below.

Table 2-16. Grand Coulee Dam criteria for drum gate maintenance

February FRM Requirement for Maximum April 30 Elevation (feet) ^a	Drum Gate Maintenance ^b
≤ 1,255 feet	Yes
1,255–1,265 feet	If following year would be a forced drum gate maintenance year: Yes If following year would not be a forced drum gate maintenance year: No
> 1,265 feet	If in forced drum gate maintenance year: Yes If not in forced drum gate maintenance year: No

^a Maximum April 30 GCL Elevation based on the February official April–August water supply forecast for The Dalles Dam the third working day of February, adjusted for available storage capacity upstream of The Dalles Dam other than Grand Coulee Dam. Monthly FRM requirements are available online at: http://www.nwd-wc.usace.army.mil/report/flood_risk/

^b Drum gate maintenance is required to meet the 1 in 3, 2 in 5, and 3 in 7 criteria.

- If the February forecast sets the Grand Coulee April 30 FRM elevation at or below 1,255 feet, Grand Coulee Dam will be drafted to perform drum gate maintenance.
- When the February forecast sets the April 30 FRM requirement above 1,265 feet, drum gate maintenance will be forced only if needed to meet the requirements of the 1 in 3, 2 in 5, and 3 in 7 criteria.
- If the April 30 FRM requirement is between 1,255 and 1,265 feet, maintenance will only be done if the following year would be a forced drum gate maintenance year. For example, if maintenance is deferred in year 1 because of dry conditions, and the forecasted FRM elevation is between 1,255 feet and 1,265 feet in year 2, then drum gate maintenance would be accomplished in year 2 to avoid forced drum gate maintenance in year 3, regardless of water supply conditions. The example above illustrates the 1 in 3 criteria, but the 2 in 5 and 3 in 7 criteria would also need to be checked.

2.4.4.3 John Keys III Pump-generating Plant

The pumping plant consists of six pumps that pump water from Lake Roosevelt to Banks Lake, and six pumped storage hydropower (PSH) turbines that can pump water to Banks Lake or generate power with water released from Banks Lake back to Lake Roosevelt. The majority of the scheduled maintenance occurs outside of the irrigation season, to the extent practicable. Typically, one or more pumps and/or PSH turbines are offline during any given time during the year. However, during the irrigation season when pumping demand is much higher, it is desirable to have the majority of this equipment available.

2.4.4.4 Non-routine Maintenance at Facilities on and Around Banks Lake

Banks Lake, an offsite equalizing reservoir, is located in the upper Grand Coulee (an ancient river bed) and was built to store and supply irrigation water to the Columbia Basin Project. Banks Lake is formed by the construction of two dams: North Dam, which is near Grand Coulee Dam, and Dry Falls Dam, which is at the south end of the reservoir. For irrigation supply to the Columbia Basin Project, water is released from Banks Lake through a set of gates at Dry Falls Dam.

Bulkheads are available to isolate the canal headworks and reduce the need for drawdowns to perform maintenance on the canal headworks. However, other maintenance needs may require that Banks Lake be significantly drafted, up to 35 feet. The full hydrologic effects of the maintenance operations would start in August by reducing pumping or shutting off the pumps from Lake Roosevelt and allowing irrigation withdrawals to draft the lake by the end of October. This would result in a slight increase in flows in the Columbia River below Grand Coulee during drawdown because water typically pumped to Banks Lake would be passed downstream. Maintenance would be performed during the winter with the goal of being completed in the spring. Refill would be coordinated with Bonneville to take advantage of high flows and low power demand to attempt refill of Banks Lake by April 15. There would be a slight decrease in flows in the Columbia River below Grand Coulee as a result of increased pumping to refill Banks Lake.

THIRD POWER PLANT OVERHAUL

The G19 through G21 unit generators at the Third Power Plant are original and should be rewound (i.e., stator coils removed and replaced) every 30 years; thus, their life expectancies have been surpassed. Reclamation plans to modernize units G19 through G21 over a 10-year period beginning in 2020 and ending approximately by 2030. The modernization would allow each unit to have a life expectancy of approximately 40 years (Reclamation 2019).

No water quality impacts from operation activities are anticipated during the overhaul of the Third Power Plant generating units. Current operation and maintenance (O&M) schedules attempt to keep at least five Third Power Plant units in production during the months of December through August. More than one unit are typically removed from production in the fall months to perform needed maintenance. Joint operations with the Corps and Chief Joseph Dam can continue uninterrupted, minimizing spill events at Grand Coulee Dam and consequently minimizing TDG generation below the dam. This would not change during the overhaul and modernization of the individual Third Power Plant units. As a result, the effect on water temperature from operations throughout the overhaul period would be similar to the effect on water quality conditions from the existing conditions in both the reservoir and in the river below the dam.

LEFT AND RIGHT POWER PLANTS OVERHAUL

The Left and Right Power Plant Units 1–18 have reached their design life and are scheduled to be overhauled over a 10-year period starting in 2019 or later. The objective of the overhauls is to repair and restore these machines to assure their reliable operation for an additional 30 years. In 2018, Reclamation completed an environmental assessment for this extraordinary maintenance (Reclamation 2019). No water quality impacts from the overhaul project anticipated.

JOHN W. KEYS III PUMP-GENERATING PLANT MODERNIZATION

The 12 units that compose the JWKIII show problems stemming from wear and design that require more frequent maintenance, more challenging repairs, and longer down times. As a result, these and other components contribute to growing safety-related concerns at the plant, increase the plant operational costs, create limitations on day-to-day plant operations, and impose risks to sustained long-term

operation of the plant. These issues threaten Reclamation's contractual obligations to provide on-demand delivery of irrigation water and accommodate pumped storage at Banks Lake for balancing reserves and electrical load shaping. Modernization improvements and upgrades will not change the essential operation of Banks Lake, according to existing protocols for irrigation, load shaping, and balancing reserves; however, they may enable more rapid transitions and/or more frequent incremental changes in daily reservoir levels, while the overall reservoir levels remain within established operating norms.

Modeling to support the modernization of the JWKIII (Reclamation 2012) demonstrates that pump/generating scheduled to take advantage of off-peak hour pricing to increase inflows, and then generate with the pumps/generators when power demands are high, results in more fluctuation of lake elevation but still maintains the elevation within the normal operating range. Model results show that the proposed modernization of the JWKIII would not significantly change Banks Lake elevations. Banks Lake elevations would remain within the operating range of elevation 1,565 feet to elevation 1,570 feet throughout the year. Irrigation deliveries to the Columbia Basin Project would be unaffected. The summer draft to elevation 1,565 feet for flow augmentation would be unaffected.

2.4.5 Chief Joseph Dam

2.4.5.1 Powerplant Maintenance

Turbine and generator maintenance at Chief Joseph Dam is conducted on regular schedules ranging from annually to every 5 years, but this can vary. Five or more of the 27 units may be offline at a time, and maintenance outages may happen at any time of year. A developed protocol requires that when a turbine is dewatered for maintenance, any stranded fish in the remaining pool of water at the bottom of the draft tube are collected and released downstream. The protocol has been coordinated with the FPOM coordination team and is included as an appendix in the annual FPP.

2.4.5.2 Spillway Gate Maintenance

Spillway gates may be out of service for maintenance. This may coincide with the spill season, but there are 19 total spill bays, and all are equipped with flow deflectors, which provide TDG abatement downstream, if spill is necessary.

2.4.6 Dworshak Dam

2.4.6.1 Power Plant Maintenance

At Dworshak Dam, there are three generating units, which discharge into the North Fork of the Clearwater River. During the months of September through January, units are taken down, one at a time, to perform annual inspection and maintenance. Each unit is typically out of service for 2–4 weeks during this annual inspection and maintenance. Similar to turbine maintenance at Chief Joseph Dam, fish protection protocols have been developed for turbine dewaterings at Dworshak Dam. These protocols are included in the FPP and 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.

2.4.6.2 Routine Maintenance

Every fall, one of the generating units is brought down for six weeks for cavitation repair. This outage is scheduled first, because the turbines must be dewatered to provide access. Appendix I of the FPP (<https://pweb.crohms.org/tmt/documents/fpp/>) provides the details of turbine maintenance undertaken at Dworshak Dam to minimize impacts on fish.

Several constraints impact maintenance scheduling at Dworshak Dam. In the spring, the project is required to adhere to a published FRM curve. In the summer, Dworshak's water is used to regulate downstream river temperature and improve flows for fish passage. For both operations, to the maximum extent possible, water is passed through the three generating units and is not spilled to avoid elevating TDG saturations above the maximum standard of 110 percent saturation. This means routine turbine maintenance cannot be scheduled during spring or summer.

Some SR steelhead, B-run have been incidentally killed during turbine maintenance and testing activities at Dworshak Dam. Changes in maintenance operations and improvements in protocols provided in the FPP resulted in fewer than 10 mortalities in 2017 and 2018. To further minimize and avoid SRB injury and mortality, the Corps will continue to implement and improve protocols regarding Dworshak Dam turbine unit O&M and associated FPOM coordination, consistent with the 2019 FPP (http://pweb.crohms.org/tmt/documents/fpp/2019/final/FPP19_Final_071119.pdf).

2.4.7 Lower Columbia River and Lower Snake River Dams

2.4.7.1 Power Plant Maintenance

Power plant maintenance is normally timed to minimize the impacts of the interruption of all applicable project purposes. For example, to the extent practicable, maintenance is scheduled to minimize impacts on adult and juvenile fish passage during spring and summer (April–August), i.e., annual outages for maintenance of priority turbine-generator units and related equipment are normally scheduled in late summer and fall. Maintenance of priority units is scheduled during the winter or when fewer fish are passing the project, to the extent possible. Annual outage schedules are prepared each winter and discussed with the region. Schedules are updated throughout the year to reflect maintenance requirements and are provided to the Corps' Reservoir Control Center for regional coordination through the appropriate teams under the Regional Forum, such as the FPOM coordination team and TMT.

Maintenance of turbine units may or may not require them to be dewatered. Dewatering is normally conducted only when personnel need to enter the waterways of the turbine intake to inspect or work on the turbine itself, or if the turbine and generator must be disassembled for major repair work. Stoplogs and operating (intake) gates are installed for safety precautions when maintenance activities require that the turbine units not turn for any reason. Projects have written dewatering plans that detail how to dewater turbine units to minimize impacts to fish. These plans detail how to operate the turbine units and install stoplogs to minimize fish entrainment in the units and how to handle fish when they are encountered during the dewatering process. Project fishery biologists or trained natural resources

personnel monitor turbine dewatering events and oversee the fish removal process pursuant to dewatering plans developed for each project.

Testing of major generating equipment may require special project operations. Electrical testing of generator step-up transformers requires that the transformers be disconnected from the transmission lines. With the exception of the first powerhouse at Bonneville Dam, all of the lower Columbia River projects have two or more transmission lines per powerhouse, so an outage required for transformer insulation testing does not require an outage of more than four turbine-generators. Dams on the lower Snake River, other than Ice Harbor, take the entire powerhouse offline for Doble (transformer performance) testing. Testing is normally scheduled in late summer due to the requirement of warm and dry conditions and a 5-day outage to complete the tests. The timing of tests is set to minimize impacts on migrating fish and to keep local dissolved gas levels within allowable limits. Periodic testing of other generation-related equipment may require short-term departure from normal operating criteria.

Over the last several years, the Corps has taken steps to address concerns about releases of oils and greases from the lower Columbia and lower Snake River dams. The Corps has applied for National Pollutant Discharge Elimination System permits for discharges of pollutants, including oil or grease, from appropriate point sources. For equipment in contact with the water, the Corps implements best management practices to avoid accidental releases and to minimize any adverse effects in case of an accidental release. The Corps has begun using “environmentally acceptable lubricant” greases where technically feasible, and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and is implementing oil accountability plans that include enhanced inspection protocols and preparation of annual oil accountability reports. In light of these best management practices with respect to the use of oils and greases to maintain equipment at the dams, any effects on migrating salmon and steelhead are both discountable and insignificant.

2.4.7.2 Navigation Lock Maintenance

A 2-week annual maintenance outage for all eight lower Columbia River and lower Snake River locks normally occurs in March. Both routine and non-routine lock maintenance occurs at this time. Work includes inspections and maintenance of underwater filling and emptying conduits, tainter valves, gates, and gate operating equipment. Each lock is dewatered on a 5-year rotation for major inspection. Other inspections take place annually. Special reservoir levels may be required prior to and after lock outages in order to move floating bulkheads out of and back into their mooring berths. Routine maintenance that does not require outages takes place during other times of the year as well. Additional non-routine inspections or maintenance may take place during the year if problems are encountered with any of the locks’ operating equipment. If gate problems are encountered during the year, floating bulkheads may need to be used to lock vessels through while repairs are made. This may require a short-term full-pool operation of the reservoir (potentially including a deviation from the maximum range of effective operating pool elevations implemented during fish passage season) in order to move the floating bulkheads into or out of position. Once in position, the floating bulkhead can be used for locking vessels through the lock at any normal pool elevation. Periodic maintenance dredging is performed to maintain the federal navigation channel at authorized dimensions.

During the navigation lock outages and dewaterings, there may be ESA-listed steelhead and bull trout at some sites, so the work may affect ESA-listed fish. Any fish encountered during lock draining would be netted and returned to the river. Unanticipated non-routine maintenance could occur during the fish passage season at any lock and could affect juvenile fish transport operations.

2.4.7.3 Fish Passage Facility Maintenance

Powerhouse or control room operators or project fish biologists inspect the operations of fish passage facilities several times per day. Any deficiencies observed during inspections are corrected as soon as is practicable. Maintenance activities to support fish passage operations, structures, and passage facilities are completed in accordance with the FPP. Typically, these maintenance activities occur during the winter months, but they can occur at other times following established regional coordination through groups such as the FPOM coordination team and/or TMT. The range of activities varies based on the specific project facilities and fish passage features. All routine maintenance activities or facility modifications that require the dewatering of facilities or that may affect the operation of facilities are scheduled for winter periods (Table 2-17).

Table 2-17. Adult and juvenile fish passage facilities winter maintenance periods for lower Columbia and lower Snake River projects, 2019–2020 (from 2019 Fish Passage Plan)

Dam	Winter In-Water Maintenance Window (adult)	Winter In-Water Maintenance Window (juvenile)
Bonneville	12/01/2019–02/29/2020	12/01/2019–02/29/2020
The Dalles	11/30/2019–02/27/2020	11/30/2019–03/29/2020
John Day	11/30/2019–02/29/2020	11/30/2019–03/29/2020
McNary	01/01/2020–02/29/2020	12/15/2019–03/31/2020
Ice Harbor	01/01/2020–02/28/2020	12/16/2019–02/28/2020
Lower Monumental	01/01/2020–02/28/2020	12/16/2019–03/30/2020
Little Goose	01/01/2020–02/28/2020	12/16/2019–02/28/2020
Lower Granite	01/01/2020–02/28/2020	12/15/2019–03/22/2020

The FPP contains criteria for how to operate fish passage facilities during the normal operating season if a facility component fails and there may be an impact on facility operations or fish passage. The FPP also contains criteria for coordinating facility operations or fish passage issues with regional parties and how to operate facilities during major component failures.

ADULT FISH PASSAGE FACILITY MAINTENANCE

Generally, all adult fish ladders are dewatered for a brief period each winter. During the outages, project personnel inspect the fish passageways, remove any debris encountered, and maintain all ladder and fish counting equipment. Annual maintenance on auxiliary water supply pumps and fish turbines is also conducted during the winter maintenance period. Project personnel inspect diffuser gratings each year,

either by dewatering the collection channels and inspecting directly or by using an underwater camera or divers. Any deficiencies found during winter maintenance periods are repaired or corrected. For projects that have two or more adult ladders (i.e., all projects except Little Goose and Lower Granite), one ladder is kept in operation at all times.

Periodic maintenance of adult fishway equipment that does not seriously affect facility operations or fish passage may also be performed during the fish passage season. Some fishway equipment requires periodic lubrication, adjustment, or other preventative maintenance type of work that must be done during the fish passage season for continued operations. Other maintenance activities, such as cleaning debris off fish ladder exit trashracks or fish counting station picketed leads, are done on an as-needed basis to maintain the facilities within established operating criteria.

At Bonneville Dam, periodic dredging in the forebay is required to ensure reliable operation of the Bradford Island Fish Ladder. The area near the exit of the fish ladder is surveyed annually and material is dredged every year or two. 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 takes one week to complete and would continue to be conducted during the in-water work period (December–March), in accordance with the FPP.

Also at Bonneville Dam, periodic dredging in the forebay is required to ensure reliable operation of the Washington Shore Fish Ladder. The area near the fish units that supply attraction water to the fish ladder is surveyed annually and material is dredged every year or two. 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 takes one week to complete and would continue to be conducted during the in-water work period (December–March), in accordance with the FPP.

JUVENILE FISH PASSAGE FACILITY MAINTENANCE

Annual maintenance of JBSs requires the removal of fish screens from turbine intakes and the dewatering of juvenile fish collection channels, dewatering structures, and various fish transportation and/or sampling facilities. After the facilities are removed from service, they are inspected, and repairs and annual maintenance are performed. Overhauls and/or modification of facilities take place during the annual maintenance period, as well. At projects that have juvenile fish transportation facilities, those facilities, along with transport barges and trucks, are also maintained. The fish passage equipment is all placed back in service before the beginning of the next operating season.

JBSs require almost continuous oversight and maintenance during the operating season. Juvenile fish transportation facilities and monitoring facilities are staffed either 24 hours per day or when they are collecting fish for sampling, to assure they operate according to established operating criteria. Fishway passages (gatewell orifices, flumes, separators, and piping) must be checked for debris and other obstacles that may injure juvenile fish. Some fish screens (submersible traveling screens and extended-length submersible bar screens) have automated systems connected to them to assure that they are operating as programmed. The automated systems assure that mesh rotates as planned on submersible traveling screens or the cleaning brushes cycle on extended-length submersible bar screens to keep screens free of debris.

At the Bonneville Dam second powerhouse, the vertical barrier screens (VBSs) at turbine units require drawdown monitoring to detect VBS plugging. Water level monitors relay drawdown information to the control room and an alarm is activated when drawdown criteria are exceeded, meaning the VBSs need to be cleaned. When automated systems and visual monitoring indicate a screen failure, the associated turbine unit is operated according to criteria in the FPP, and the VBS or submersible traveling screen is repaired as soon as practicable. Fish screens are also inspected by either maintenance personnel or biologists, using underwater cameras, on a monthly basis to assure they are operating correctly.

Spill operations at Bonneville Dam routinely pull large rock material onto the spillway apron. This material must be 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, typically in September, and will typically take one day to complete. Rock material would occur during the in-water work period (December–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.

2.4.7.4 Non-routine Maintenance

- Install IFP turbines at Ice Harbor, John Day, and McNary Dams (Improved Fish Passage Turbines). Many hydroelectric turbines are approaching the end of their design life and will continue to be replaced in sequence if warranted. Where feasible, the Action Agencies intend to install more efficient, IFP turbine units when the time comes for the units to be replaced. Recent advances in turbine design have facilitated development of turbines that create hydraulic conditions that are better for fish and also improve hydroelectric generation efficiency. Turbines would be replaced over time; replacement is already under way at Ice Harbor Dam and planned to begin at McNary Dam after the completion of the turbine design that is also ongoing. John Day Dam will undergo installation of IFP turbines within the timeframe covered by this consultation.
- Little Goose Dam jetty and retaining wall repair. The Corps will repair the existing jetty and retaining wall located near the north shore adult ladder entrance at Little Goose Dam where erosion has occurred.

2.5 STRUCTURAL MEASURES TO BENEFIT PACIFIC LAMPREY

This section includes structural measures designed to improve passage and survival of Pacific lamprey (*Entosphenus tridentatus*) through the lower Columbia and lower Snake River dams. These measures, which build upon similar modifications that have been implemented since the early 2000s, were identified in the CRSO EIS. The Action Agencies propose to implement these measures as funding becomes available. While all measures are intended to benefit Pacific lamprey, some may also provide passage benefits to anadromous salmon, steelhead, and bull trout. Any structural or operational changes intended to improve passage conditions for Pacific lamprey will be coordinated with the Services via the appropriate regional coordination forums (e.g., the FPOM coordination team, Fish Facility Design Review Work Group [FFDRWG]) to assure neutral to beneficial effects on ESA-listed species.

- Modify turbine intake bypass screens that cause juvenile lamprey impingement and entanglement (Bypass Screen Modifications for Lamprey). This measure would replace existing turbine intake bypass screens used to divert fish into the collection channel of the JBS. 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.
- Modify the control sections (serpentine weirs) of Bonneville Dam fish ladders (Modify Bonneville Ladder Serpentine Weir). This measure would modify the serpentine-style flow control sections of Bonneville Dam's Washington Shore and Bradford Island fish ladders, converting them to Ice Harbor-style vertical slot with submerged orifices configurations. This would improve passage conditions for adult lamprey and likely reduce stress and delay for adult salmon, steelhead, and bull trout. All full-duplex passive integrated transponder (PIT) arrays currently located in the control sections of these ladders would be replaced in kind or improved to maintain or enhance current levels of detection of PIT-tagged anadromous fish.
- Expand network of Lamprey Passage Structures (LPSs) to bypass impediments in existing fish ladders (Lamprey Passage Structures). Ramp-like flume structures would be installed or modified in fish ladders at Bonneville, The Dalles, and John Day dams to guide adult lamprey out of fish ladders and into parallel systems for volitional passage or collection for upstream transport or passage studies. The LPSs would use independent water sources (pumps or gravity-flow systems) and may be placed in various locations within fish ladders, such as collection channels, junction pools, and auxiliary water supply channels. New structures may be installed at Bonneville Dam's Bradford Island and Washington Shore fish ladders, The Dalles Dam's east fish ladder, and/or John Day Dam's south fish ladder. At John Day Dam, the existing lamprey passage structure on the north fish ladder may be extended from the tailrace deck to the forebay.
- Modify turbine cooling water strainer systems to safely exclude Pacific lamprey and other juvenile fish (Turbine Strainer Lamprey Exclusion). This measure would install structures to prevent juvenile lamprey, juvenile salmonids, and other fish from being entrained into the intakes of turbine unit cooling water systems. Hood-like structures would be installed over existing intake gratings at all lower Snake and lower Columbia River dams, and would allow sweeping flows to move fish past the opening, thereby reducing entrainment and related risk of fish injury or mortality.
- Modify existing fish ladders, incorporating lamprey passage features and criteria into ladder modifications (Lamprey Passage Ladder Modifications). This measure would modify existing fish ladders at the lower Columbia and lower Snake River dams to improve passage conditions for adult lamprey. While other novel designs may be developed and installed (in coordination with the Services), modifications may include the following:
 - Install ramps to salmon orifices at Bonneville Dam (Salmon Orifices). Install concrete or aluminum ramps in the Bradford Island Fish Ladder to make salmon orifices elevated above fish ladder floors more accessible to lamprey. Ramps would enable adult lamprey to more

easily and directly access the salmon passage openings by removing right angles at the approach.

- Continue to install diffuser grating plating (Diffuser Grating). At Bonneville Dam (Bradford Island and Cascades Island fish ladders), The Dalles Dam (North Fish Ladder), and Lower Monumental Dam (North and South fish ladders), where feasible, install steel plating over floor diffuser grating immediately adjacent to submerged weir orifices within the existing fish ladders. Floor diffusers add water to the fish ladder to provide attraction flows for fish, but the grating makes it difficult for lamprey to attach as they attempt to pass through submerged weir orifices. This plating would provide an attachment surface for lamprey to attach and rest as they swim upstream through the fish ladder.
- Install additional refuge boxes at Bonneville Dam (Refuge Boxes). At Washington Shore and Bradford Island fish ladders, install metal refuge boxes or similar structures on the floors or walls of fish ladders to provide a protected resting environment for lamprey migrating upstream.
- Install an additional wetted wall or similar structure at Bonneville Dam (Wetted Wall). At the Bonneville Dam Washington Shore Fish Ladder, install a metal wall in the control section of the fishway (similar to the structure already installed in the Bradford Island Fish Ladder). This would provide an alternate upstream passage route for migrating adult lamprey and allow the lamprey to escape the higher water velocities and turbulence in the adjacent control section of the fish ladder. If the control sections of the Washington Shore or Bradford Island ladders are rebuilt (per the measure above), wetted wall structures may be removed.
- Install rounded entrance weir caps at McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. Round the edges at fish ladder entrance weirs to eliminate 90-degree corners, which hinder lamprey from entering fish ladders on the lower Snake projects and at McNary Dam. Rounding these edges would give lamprey a constant attachment surface to accommodate the high-water velocities encountered at fish ladder entrances. Modifications would be designed to maintain existing fishway entrance criteria for ESA-listed salmon and steelhead, as described in the annual FPP.
- Install closeable gates on Bonneville Powerhouse 2 floating orifice gates to reduce the loss of lamprey from the collection channel of the Washington Shore Fish Ladder (Closeable Gates). Structural modifications would allow seasonal closure of up to eight Floating Orifice Gates during the lamprey passage season. Any changes to annual FPP operations would be coordinated with the Services via the FPOM coordination team

2.6 NON-OPERATIONAL CONSERVATION MEASURES TO BENEFIT ESA-LISTED FISH

This section on non-operational conservation measures to benefit ESA-list fish has three parts: salmon and steelhead, Kootenai River white sturgeon, and bull trout. The Action Agencies' approach to mitigating the effects of CRS management on these ESA-listed species is consistent with conservation strategies established in regional recovery planning processes. The Action Agencies propose to continue

to address uncertainty regarding effects of further spring spill increases, any residual adverse effects of system management, and climate variability.

2.6.1 Non-operational Conservation Measures for ESA-listed Salmon and Steelhead

Non-operational measures for ESA-listed salmon and steelhead include structural measures, conservation and safety-net hatchery programs, predation management, and habitat improvement actions. Targeted research, monitoring, and evaluation (RM&E) to support in-season and annual adaptive management is part of many of these measures.

2.6.1.1 Structural Measures

Besides specific storage and run-of-river dam operations, other measures are proposed to benefit ESA-listed fish in the Proposed Action. While many of these measures are primarily designed to improve passage conditions or otherwise reduce stress or delay of ESA-listed anadromous salmon and steelhead through the lower Columbia and lower Snake River dams, several may also provide benefits to resident bull trout. While all measures listed below include structural elements, some also include monitoring or operational elements.

- Adult fish ladder temperature differentials. Consistent with the recommendations presented in NMFS' 2015 Adult Sockeye Salmon Passage Report (NMFS 2016), the Corps will continue the following actions:
 - Continue monitoring and reporting of all mainstem fish ladder temperatures and identify ladders that have substantial temperature differentials (>1.0°C).
 - Where beneficial and feasible, develop and implement operational or structural solutions to address maximum temperatures and temperature differentials in adult fish ladders at mainstem lower Snake and Columbia dams identified as having these problems.
 - After development of a contingency plan by NMFS and state and tribal fish managers, complete an alternatives study to assess the potential to trap-and-haul adult sockeye salmon at lower Snake River dams. The alternatives study would recommend the least-cost method to meet the goal and objectives of a contingency plan.
 - Maintain adult trapping capabilities at Ice Harbor Dam. The Corps will maintain or improve the adult trap at Ice Harbor Dam to allow for emergency trapping of adult salmonids as necessary. The Corps may refurbish the trap in the future to prepare for the implementation of emergency trap-and-haul activities (e.g., sockeye during high temperature water years similar to 2015).
- Adult separator at the Lower Granite Dam Juvenile Bypass System. The Corps will complete follow-on modifications to new Lower Granite Dam JBS separator to reduce delay, injury, and stress to salmon and steelhead, bull trout, and non-target species.
- Lower Granite Dam adult fish trap improvements. The Corps will design and implement cost-effective structural modifications to the Lower Granite Dam adult fish trap to reduce delay and stress for adult salmonids and non-target species such as Pacific lamprey.

- Enhanced debris management at lower Snake River and McNary projects. Seasonally, pulses of woody debris and vegetation (both aquatic and terrestrial) enter the Snake River and drift downstream. This debris can accumulate on turbine unit trash racks and enter bypass systems and can injure ESA-listed salmonids. Woody debris causes considerable O&M challenges for dam operators. Corps personnel use trash rakes and other tools to remove debris from trash racks and gatewells. Air burst systems are used to flush debris from orifices that guide fish from gatewells into bypass systems. In recent years, Lower Granite Dam's removable spillway weirs (RSWs) have effectively passed large amounts of debris, increasing debris loads at downstream lower Snake River dams and McNary Dam. In response, the Corps, in coordination with NMFS and the FPOM coordination team, 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 McNary Dam and the lower Snake River dams. Where necessary and feasible, the Corps will design and implement cost-effective solutions designed to minimize and reduce ESA-listed salmonid injury and mortality associated with debris accumulation.

2.6.1.2 Conservation and Safety-net Hatchery Actions

The Action Agencies will continue to fund the O&M 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. These programs are helping to rebuild and enhance the naturally reproducing ESA-listed fish in their native habitats using locally adapted broodstocks, while maintaining genetic and ecologic 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 broodstocks to increase the abundance of the species at risk.

The conservation and safety-net hatcheries to be funded under the Proposed Action are listed in Table 2-18. These programs have undergone separate, program-specific ESA consultations with NMFS. The programs will be operated in accordance with those BiOps. RM&E relevant to each hatchery program have been incorporated into the relevant hatchery program BiOp(s). The Action Agencies will continue to discuss broader, basin-wide, hatchery monitoring needs as they come up and collaborate with NMFS to evaluate ways to support these needs to the extent practicable.

Table 2-18. Conservation and safety-net hatchery programs included in this consultation

Species	Hatchery Program	Population	Program Type	Operator	Action Agency Funding Source	NOAA BiOp Status	USFWS BiOp Status	Production Level Approved in NMFS BiOp
Upper Columbia spring Chinook ^a	Winthrop NFH Spring Chinook Program ^a	Methow spring Chinook	Integrated conservation	USFWS	Reclamation	Final BiOp 10/13/2016		Up to 400,000 smolts
Upper Columbia steelhead ^a	Winthrop Steelhead Program	Winthrop steelhead	Integrated conservation	USFWS	Reclamation	Final BiOp 10/10/2017		Up to 200,00 smolts
Upper Columbia spring Chinook	Chief Joseph Hatchery Program/Winthrop NFH	Okanogan spring Chinook	Isolated conservation (10j)	Colville Tribe/USFWS	Bonneville/Reclamation	Final CJH BiOp 10/27/2014 Final BiOp WNFH 10/13/2016		Up to 200,000 smolts
Snake River spring Chinook	Johnson Creek Spring Chinook Program	Johnson Creek	Integrated Recovery	NPT	Bonneville	Final BiOp 11/27/2017	Final BiOP 12/08/2017	Up to 150,000 smolts
Snake River fall Chinook	Nez Perce Tribal Hatchery Fall Chinook Salmon Program	Clearwater basin	Integrated Recovery	NPT	Bonneville	Final BiOp 8/13/2018	Final BiOP 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	IDFG	Bonneville	Final BiOp 9/28/2013	Final BiOP 12/18/2017	Up to 1,000,000 smolts

BiOp = biological opinion; IDFG = Idaho Fish and Game; NFH = National Fish Hatchery; NPT = Nez Perce Tribe; USFWS = U.S. Fish and Wildlife Service

^a The upper Columbia spring Chinook and steelhead hatchery programs included in this table serve as conservation programs as well as the Grand Coulee mitigation programs

2.6.1.3 Predation Management

PINNIPED PREDATION MANAGEMENT AT BONNEVILLE AND THE DALLES DAMS

To reduce the number of ESA-listed salmon and steelhead impacted by pinnipeds (primarily California sea lions and Steller sea lions) at fish ladder entrances at Bonneville and The Dalles Dams, the Action Agencies will implement the following measures:

- The Corps will 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. However, 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. 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.
- The Corps will continue to provide the Oregon Department of Fish and Wildlife (ODFW), WDFW, and Columbia River Inter-Tribal Fish Commission personnel with access to Bonneville Dam and the Bonneville Dam boat restricted zone, as appropriate, to support sea lion predation management. When practicable, the Corps will provide crane and other operational support to fish and wildlife management personnel during sea lion dissuasion and/or removal operations.
- The Action Agencies will, in coordination with NMFS, review the Corps' current (i.e., 2019) Bonneville Dam pinniped predation monitoring objectives and develop and implement a revised monitoring plan that reflects current and near-future management needs. This monitoring plan will be included as an appendix in the annual FPP and will identify monitoring objectives (e.g., daily pinniped abundance), monitoring dates, and reporting requirements. The Corps will continue to monitor pinniped activity at Bonneville Dam annually and will provide an annual report to NMFS and monthly reports to the FPOM coordination team. The Corps may, in coordination with NMFS, adjust the monitoring plan periodically to meet current management needs. Changes to the plan will be reflected in the annual FPP.
- The Corps will continue to 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.

PIKEMINNOW PREDATION MANAGEMENT

Since its inception in the early 1990s, the Northern Pikeminnow Management Program (NPMP) has removed more than 5.1 million Northern pikeminnow from the Columbia and Snake Rivers. Evaluation indicates that pikeminnow predation on juvenile salmon has declined by about 40 percent, saving three to five million juvenile salmon annually that would otherwise have been consumed by pikeminnow. Bonneville will continue to fund, implement, and report on the NPMP, which consists of the Northern Pikeminnow Sport Reward Fishery and the Dam Angling programs. The area included in the Northern Pikeminnow Sport Reward Fishery is the mainstem Columbia River from the estuary to Priest Rapids

Dam, and the Snake River up to Hells Canyon Dam. This program depends on the public to remove 10 to 20 percent of predatory-sized pikeminnow per year from May through September. The Northern Pikeminnow Sport Reward Fishery is proposed to continue as implemented in the previous BiOp; administered by the Pacific States Marine Fisheries Commission in cooperation with WDFW and ODFW. Program evaluation, population indexing, tagging, and monitoring of other predator response is conducted by ODFW, while WDFW implements the public fishery by staffing the registration stations, collecting and disposing of pikeminnows caught, and issuing reward vouchers. The Dam Angling Program consists of two crews of anglers hired by WDFW to fish for Northern pikeminnow from the dam faces of The Dalles and John Day dams from May through October.

During the period covered by this consultation, the Action Agencies will work with partners to understand new management opportunities (i.e., revised sampling methods to replace electrofishing) and adaptively manage the Dam Angling Program component to address new site-specific predation concerns, where feasible. Specifically, for 2020 and 2021, dam angling will include the addition of test fisheries along Snake River hydroelectric projects with rotating crews at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. Small (2-3 person) crews will explore feasibility/opportunities along turbine decks with current preferred angling technique (recreational-hook and line back bouncing). The Action Agencies will coordinate with the Services locations of future actions within Dam Angling Program, especially if new site-specific predation locations become a priority.

In addition, due to concerns regarding electro-fishing related to the sport reward fishery program, the Action Agencies will work with regional partners to develop a plan during 2020–2022 to replace electrofishing. The Action Agencies are committed to working to identify cost effective tools that help maintain program goals while minimizing associated impacts.

AVIAN PREDATION MANAGEMENT AND MONITORING ACTIONS

Since the early 1990s, the Action Agencies have been conducting research, monitoring and evaluations of colonial water birds, (e.g., double-crested cormorants, Caspian terns, ring-billed and California gulls, and American white pelicans), and management actions to reduce predation rates on ESA-listed salmon and steelhead from the Columbia Plateau to the estuary. Three management plans were established during previous consultations, in coordination with NMFS and other regional partners, and include two plans in the estuary: the *Double-Crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement* (Corps 2015c) and the *Caspian Tern Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement* (USFWS 2005; Corps 2013) and one additional plan in the Columbia Plateau, the *Inland Avian Predation Management Plan, Environmental Assessment* (Corps 2014). In addition to the implementation of these three plans and associated NEPA documents, the Corps has executed site specific management actions at many CRS dams.

Inland Avian Predation Management

Action Agencies will continue to implement the *Inland Avian Predation Management Plan (IAPMP)*. The management goals of the *Inland Avian Predation Management Plan* were to reduce the number of Caspian tern breeding pairs in the Columbia Plateau to ≤ 200 pairs; reduce predation rates per nesting

colony to less than 2% per ESU (e.g., Snake River steelhead), and reduce the total number of breeding pairs at each colony to less than approximately 40 pairs of nesting Caspian terns.

Reclamation will continue passive and active dissuasion efforts on Goose Island. The timing and duration of the proposed work has been coordinated with the USFWS to ensure the work will be effective in maintaining the management objectives of less than 40 breeding pairs at Goose Island, consistent with the IAPMP.

The Corps will monitor tern use of Crescent Island on an annual basis to determine whether objectives of the *Inland Avian Predation Management Plan* continue to be met (i.e. less than approximately 40 pairs of nesting Caspian terns) and coordinate with the Services as warranted.

Caspian Tern Predation Management at East Sand Island

The Action Agencies will continue to fund and implement the Caspian tern dissuasion and monitoring efforts at East Sand Island as described in the *Caspian Tern Management Plan*. The management goal of the *Caspian Tern Management Plan* was to reduce the nesting habitat on East Sand Island to 1.0 acre, with an anticipated benefit of reducing predation on juvenile salmon and steelhead by reducing the number of terns nesting in the Columbia River Estuary to 3,125 to 4,375 breeding pairs (Corps 2015a, b). Nesting habitat on East Sand Island was reduced to 1.0 acre prior to the 2015 breeding season following the creation and enhancement of approximately 8 acres of alternative nesting habitat in southern Oregon and northern California.

Tern nesting habitat on East Sand Island will continue to be maintained at no less than one acre (as described in a 2015 EA/FONSI, in which the selected action reduced habitat from 1.58 acres to 1.0 acre). Active hazing and passive dissuasion (e.g., ropes and flagging, native plantings, or other structures) will continue to be used to prevent Caspian terns from nesting outside the managed one acre. The colony of Caspian terns nesting on East Sand Island was within the 3,125–4,375 breeding pairs in 2017 and 2019.

Double-crested Cormorant Predation Management at East Sand Island

The Corps will continue to implement the *Double-crested Cormorant Management Plan*. The goal of the *Double-crested Cormorant Management Plan* was to reduce the predation of juvenile salmonids in the Columbia River Estuary by reducing population of double-crested cormorants nesting on East Sand Island to 5,380–5,939 breeding pairs. The plan was implemented in two phases: Phase I was implemented between 2015 and 2017 and consisted of lethally culling adults and oiling eggs to reduce the breeding population on East Sand Island; Phase II activities were initiated in 2018 and consist primarily of non-lethal actions, including habitat modifications and hazing, supported with limited egg take to ensure the number of cormorants on East Sand Island does not exceed 5,380–5,939 breeding pairs.

Habitat on East Sand Island was modified between January and March 2019 to reduce the availability of nesting habitat to 1.04–1.15 acres (or less). Long-term management activities will continue in a manner consistent with the management plan to ensure the colony size estimate does not exceed a threshold of 5,380 to 5,939 nesting pairs. Limited egg take (up to 500 eggs on East Sand Island) is used to restrict DCCO from nesting in other or new areas on ESI. Nesting habitat on East Sand Island will remain

available in order to retain colony size objectives, but no management actions would be taken to ensure a minimum colony size or to reduce double-crested cormorant abundance below the threshold stated in the *Double-crested Cormorant Management Plan*. Implementation will continue to be adaptively managed and will make use of methods that are most effective, least impactful to non-target species, and require least effort and cost. Hazing and egg take are contingent on annual depredation permits from USFWS.

Although the goal of the *Double-crested Cormorant Management Plan* to reduce the number of DCCOs nesting on ESI has been met in the last few years, avian predation on migrating salmon and steelhead in the lower Columbia River persists. The size of the DCCO colony on the Astoria-Megler Bridge has increased in every year since monitoring began in 2004 (with the exception of 2010), with the largest numerical increase in colony size occurring in 2018, when the colony more than doubled as compared to the size of the colony in 2017 (834 nests) (Turecek et al. 2018). The Double-crested Cormorant Management Plan only covers actions for the colony on East Sand Island.

Avian Predation Deterrence Operations at the Lower Columbia and Lower Snake River Dams

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Snake and Columbia River dams to reduce avian predation on juvenile salmonids. 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. Hazing typically involves launching long-range pyrotechnics at concentrations of feeding birds and occurs primarily near the spillway and powerhouse discharge areas, and juvenile bypass outfall areas. The Corps has been experimenting at McNary Dam with laser systems to haze avian predators near the bypass outfalls; if proven biologically and cost effective, this tool may be used in the future. The avian deterrent programs (including upgrades to existing facilities such as bird wires at McNary Dam and sprinklers at Ice Harbor Dam) will be coordinated through the FPOM and included in the Fish Passage Plan (for an example, see 2019 Fish Passage Plan, Appendix L, <http://pweb.crohms.org/tmt/documents/fpp/2019/>).

Avian Predation Deterrence Reservoir Operations

As described in the CRSO EIS, the Action Agencies propose to increase the normal forebay operating range at John Day Dam by two feet to increase operational flexibility (see Section 2.3.2.6 for the full description of the operations). This operation would deter Caspian terns from nesting at Blalock Island Complex and would result in decreased rates of Caspian tern predation on ESA-listed juvenile salmon and steelhead in the lower Columbia River.

Future Considerations for Avian Predation

The Action Agencies will review the most recent monitoring and effectiveness evaluation information from a regionally sponsored synthesis report (estimated completion September 2020) and determine, in coordination with NMFS and USFWS, if any additional management actions at Action Agency-managed lands are warranted. Any new actions may require additional authorizations, funding and environmental clearances. Specific actions may include:

- If tern use on Goose Island exceeds the metrics identified in the *Inland Avian Predation Management Plan* (Corps 2014), Reclamation will work with the Services to identify management actions to dissuade tern use from Potholes Reservoir before the next nesting season;
- If tern use at Crescent Island resumes and exceeds the metrics identified in the *Inland Avian Predation Management Plan* (Corps 2014), the Corps will work with the Services to address concerns, perform any necessary environmental compliance, permits and funding, if warranted;
- Further reduction of Caspian tern nesting habitat at East Sand Island (i.e., provide less than 1 acre of nesting habitat); and,
- Bonneville will continue to fund avian predation monitoring in the near term with a goal of evaluating the biological effectiveness of avian predation management actions in the Columbia River System. Bonneville will work with the Services to address the results of this monitoring and determine the need for and scope of future monitoring and evaluation.

2.6.1.4 Habitat Improvement Actions

TRIBUTARY HABITAT

The Action Agencies propose to implement targeted tributary habitat improvements during the period covered under this consultation as offsite mitigation to help address uncertainty related to any residual adverse effects of CRS management on ESA-listed migrating salmon and steelhead, including uncertainty regarding such effects in the face of climate variability. A more detailed description of the Action Agencies proposed tributary habitat actions can be found in Appendix D.

The Action Agencies annually fund numerous tributary habitat improvement actions throughout the interior Columbia River Basin. Maps depicting the geographic extent of the tributary habitat improvement program can be found in the 2016 Comprehensive Evaluation, [Figures 10 and 11, Corps et al. (2017)]. Examples of these types of tributary habitat improvement actions include the following:

- access
- habitat protection
- habitat complexity
- riparian planting
- flow
- fish screens.

The Action Agencies propose to continue to implement strategically prioritized tributary habitat improvement actions that create biological benefits for ESA-listed anadromous fish. These tributary habitat actions will be implemented in collaboration with local sponsors and using the best scientific and commercial data available to develop strategies, priorities, and improvement actions.

Long-term Goals and Objectives of the Tributary Habitat Improvement Program

The Tributary Habitat Improvement Program will be implemented in a manner directed at achieving the following long-term goals and objectives:

- Implement actions that strategically address priority limiting factors to improve population abundance, productivity, spatial structure, and diversity.
- Maintain the alignment between Tributary Habitat Improvement Program priorities and recovery plans.
- Target tributary habitat improvement actions that address priority limiting factors (i.e., key limiting factors for each population) in priority locations that will provide the greatest benefits.
- Continue to implement the Tributary Habitat Improvement Program through partnerships with stakeholders and local implementation groups.
- Use the Tributary Habitat Steering Committee established in the 2019 BiOp (NMFS 2019) for continued regional coordination between Action Agencies and NOAA Fisheries to facilitate information sharing, regional problem solving, and guide long-term planning, prioritization, and implementation of tributary habitat improvement projects.

Proposed Program Structure

The Tributary Habitat Improvement Program will be implemented using the implementation structure provided in Figure 2-24.

Salmon and Steelhead Tributary Habitat Program Steering Committee

The Action Agencies have formalized a Tributary Habitat Steering Committee (THSC) to meet a requirement of the 2019 BiOp (NMFS 2019). The THSC will include representatives from NOAA Fisheries, Reclamation, and Bonneville. The Committee's role includes the following actions:

- Oversee and guide implementation of the CRS BiOp Tributary Habitat Improvement Program in a manner that achieves the goals and objectives of the program.
- Assure effective and regular communication between NOAA Fisheries, Bonneville, and Reclamation on the Action Agencies' Tributary Habitat Improvement Program.
- Develop guidance and methods to strategically implement the tributary habitat program, including prioritizing MPG's and populations and consistent action prioritization within subbasins.
- Coordinate with the Action Agencies' Tributary Habitat RM&E program to support THSC needs.
- Establish a Science Committee that will inform the THSC as described in the following section.
- Coordinate with other technical entities throughout the Columbia River Basin such as the NOAA Northwest Fisheries Science Center, as necessary, to implement the program objectives.

- Develop an adaptive management framework for the program so that new science and learning can be effectively applied.
- Continue to support partnerships with stakeholders and local implementing groups and continue coordination between implementers and technical experts.

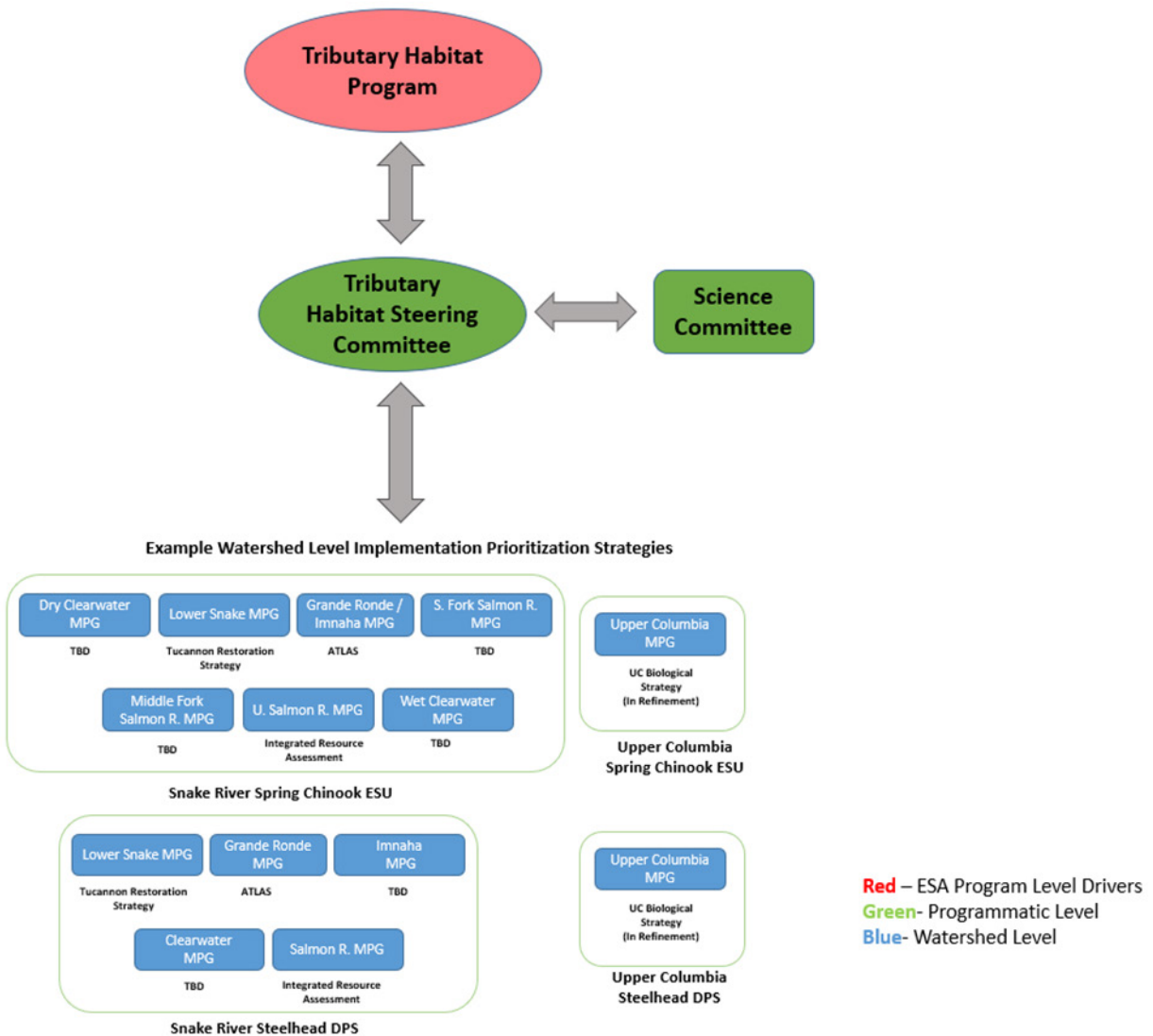


Figure 2-24. Tributary Habitat Improvement Program implementation structure

Science Committee

The science committee will provide technical input, recommendations, and quality assurance guidance to the THSC to ensure implementation of the tributary habitat program consistent with best available science to achieve the goals of the AA's tributary habitat program (see above). The specific operating rules, charter, membership, and time requirements for this team will be established by the THSC and approved by Bonneville, NOAA Fisheries, and Reclamation within the first year of implementing this Proposed Action. General functions of the team will include the following:

- Provide science-based guidance to the THSC to support implementation of the Tributary Habitat Improvement Program and to assure that the program’s goals and objectives are achieved.
- Establish a framework of “best practices” based on existing literature and contemporary, applicable examples (e.g., Puget Sound) and articulate guiding principles for habitat improvement programs.
- Make science-based recommendations to the THSC and assure that the THSC is aware of regionally applicable science.
- Provide quality assurance and guidance regarding local processes used to identify and prioritize actions to assure that they are technically sound and consistent with best practices.

Priorities

An important aspect of the Tributary Habitat Improvement Program is identification of priority populations. The basis for determining population priorities will include 1) the extent to which they are impacted by the operations of the CRS, 2) the principles regarding “focal populations” presented in Cooney (in press), 3) where applicable, ESA recovery plan documents, and 4) additional regional and local planning and prioritization documents, including ATLAS, the IRA (Integrated Rehabilitation Assessment)/MRA (Multiple Reach Assessment), and others.

These priorities will be revisited on a regular basis (most thoroughly at 5-year intervals) by the THSC and Science Committee to assure that the Tributary Habitat Improvement Program is focusing efforts where the greatest benefits to both near-term improvements and long-term recovery can be achieved. Information and accomplishments will be analyzed by the THSC with support from the Science Committee, in addition to input from the RME team and local implementers. Changes to priorities will be made as appropriate.

Proposed Actions and Metrics

For the period covered by this consultation, the Action Agencies will implement a Tributary Habitat Improvement Program. The effort will be at a similar level to that described in the 2018 proposed action and analyzed in the 2019 BiOp (NMFS 2019) and will focus on priority populations determined by the THSC based on the information and considerations described above under “Priorities.” Two metrics tables are provided below. Table 2-19 covers the proposed program metrics for the initial 5-year period of the action (2021–2026) and Table 2-20 provides projected estimates of program metrics covering the time period covered by this consultation. For additional information see “Adaptive Management of Program Performance Metrics” in Appendix D, p.24.

The tributary habitat program will be strategically implemented and resources directed towards species based on recovery priority and collective impacts of the hydro system. For lower river stocks including the Middle Columbia DPS, habitat improvement investments will continue as a component of BPA’s Fish and Wildlife program. However, Snake River and Upper Columbia listed Chinook and steelhead will be the prioritized focus for consideration in this ESA consultation. Adaptive management of population (and to some extent, MPG) priorities will be evaluated periodically by the THSC and the Science Committee to ensure they remain appropriate.

Table 2-19. Proposed habitat metrics (2021–2026) for major population groups in the Snake River and Upper Columbia spring/summer Chinook ESU and the Snake River and Upper Columbia steelhead and Middle Columbia steelhead distinct population segments (DPSs)

Major Population Group	Flow Protected (cfs)	Flow Enhanced (acre-feet)	Entrainment Screening (# screens)	Habitat Access (miles)	Stream Complexity (miles)	Riparian Habitat Improved (acres)
Snake River spring/summer Chinook major population groups						
Grande Ronde/Imnaha	79	6,893	0	49	8	140
Upper Salmon	76	9,680	24	16	6	36
Lower Snake	0	0	0	3	10	156
Upper Columbia River Spring Chinook ESU						
Upper Columbia/ East Slope Cascades	29	5,309	5	5	8	68
Snake River Steelhead DPS Major Population Groups						
Grande Ronde	79	6,893	0	54	10	356
Clearwater	0	0	0	17	6	419
Salmon	76	6360	25	30	6	326
Lower Snake	0	0	0	3	10	116
Upper Columbia River Steelhead DPS						
Upper Columbia/East Slope Cascades	42	8,254	10	35	9	109

Table 2-20. Projected estimates of habitat metrics (2021–2036) for major population groups in the Snake River and Upper Columbia spring/summer Chinook ESU and the Snake River and Upper Columbia steelhead and Middle Columbia steelhead DPSs

Major Population Group	Flow Protected (cfs)	Flow Enhanced (acre-feet)	Entrainment Screening (# screens)	Habitat Access (miles)	Stream Complexity (miles)	Riparian Habitat Improved (acres)
Snake River Spring/Summer Chinook Major Population Groups						
Grande Ronde/Imnaha	178	15,509	0	87	24	420
Upper Salmon	171	21,779	36	30	18	107
Lower Snake	0	0	0	6	29	468
Upper Columbia River Spring Chinook ESU						
Upper Columbia/East Slope Cascades	64	11,946	8	9	25	205
Snake River Steelhead DPS Major Population Groups						
Grande Ronde	178	15,509	0	96	30	1,069
Clearwater	0	0	0	31	16	1,258
Salmon	170	14,309	38	54	19	979
Lower Snake	0	0	0	6	29	349
Upper Columbia River Steelhead DPS						
Upper Columbia/East Slope Cascades	95	18,571	15	62	26	328

Implementation Process and Prioritization

The Action Agencies have been collaboratively working with local partners as described in Appendix D Supplemental Narrative for Tributary Habitat Actions to plan and implement habitat improvement actions. This has been achieved by developing limiting factors-based implementation strategies that align with ESA recovery plans, Northwest Power and Conservation Council (NPCC) sub-basin plans and existing local plans. These efforts use existing scientific data, current research, and current knowledge from local biologists to create a strategic, integrated, collaborative, and prioritized habitat implementation plan (e.g., Atlas, IRA).

The THSC will serve a critical function in the adaptive management of the proposed implementation process by providing guidance on program priorities, while also reviewing and providing input and concurrence on basin-specific implementation strategies. The THSC will leverage information and guidance from the Science Committee to assure best practices are used to integrate new research, scientific findings, and climate considerations into the proposed implementation process.

Tributary Habitat Reporting and Evaluation

Throughout the duration of the proposed action, the Tributary Habitat Improvement Program will be reviewed regularly and adaptively managed according to the process described in Appendix D Supplemental Narrative for Tributary Habitat Actions. The Action Agencies will develop, with input from NOAA Fisheries, a series of prospective 5-year implementation plans. They will also report annually on actions implemented, and at 5-year intervals they will complete a more comprehensive analysis 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 reviews.

Collectively, these annual reports and 5-year comprehensive reports will provide NOAA Fisheries with assurances that implementation is consistent with the level of effort committed to in the action. In addition, the 5-year 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). These periodic evaluations will be crucial for allowing adaptive management of the program.

The Action Agencies will work to improve reporting and sharing of information between entities. The increased use and availability of high-quality data bases in conjunction with synchronized annual reporting, improved data management, and other technology will make the 5-year rollup and analysis of metrics a more efficient, streamlined, and useful process than in previous reporting.

During the first year of the Proposed Action the THSC, in collaboration with the Science Committee, will coordinate the final requirements for both the annual and the 5-year rollup and analysis 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 Science Committee and will be updated periodically. Monitoring and Evaluation

Monitoring and Evaluation

The Action Agencies are committed to funding the tributary habitat RM&E described below, as well as engaging in a collaborative process with NOAA Fisheries, USFWS, Council, Tribes and regional partners to develop and implement a Columbia Basin tributary habitat RM&E strategy that will align with and directly support the documentation and effectiveness needs of the THSC and associated Science Committee. Bonneville commenced development of the draft Columbia Basin tributary habitat RM&E strategy in 2018 and have initiated a regional review process with NOAA Fisheries, USFWS, Council, Tribes and regional partners in 2019. After soliciting input and feedback on the draft strategy, Bonneville will complete the strategy within two years of completion of the 2020 BiOp for anadromous fish species. The anticipated level of take associated with the resulting strategy will be at or below that of the 2008 BiOp for tributary habitat RM&E. Furthermore, the Action Agencies will coordinate with NOAA Fisheries, USFWS, the THSC, and other regional partners to identify core habitat data objectives, to evaluate the success of the Action Agencies program and to support adaptive management of the ongoing habitat RM&E program and in the forthcoming strategy. Where feasible, the Action Agencies will align habitat RM&E reporting efforts to maximize the benefits of habitat RM&E in informing on the ground implementation.

The Action Agencies will implement a tributary habitat RM&E program to assess tributary habitat conditions, limiting factors, and habitat-improvement effectiveness and to address critical uncertainties associated with offsite habitat mitigation actions. Generally, this habitat RM&E program is structured to include compliance, implementation, effectiveness, and status and trends monitoring and research, all prioritized within available Action Agency budgets. The Action Agencies' efforts focus on needs included in this Proposed Action. This work is concurrent to RM&E efforts funded by other federal, state, tribal, utility, and private parties that all contribute to larger basin-wide RM&E data and analyses.

During the development of this habitat RM&E strategy, the Action Agencies will continue to fund tributary habitat RM&E to address interim needs and habitat management applications during this consultation period. This interim habitat RM&E is described by RM&E type below.

Status and trends of habitat and fish

In order to track broad-scale changes in select habitat conditions and provide data needed by NOAA Fisheries for their 5-year status assessment, Bonneville will support the annual collection of habitat status and trends information, including stream temperature and flow across the Columbia River Basin. Bonneville will explore opportunities for programmatic integration of temperature and flow data within regional data display and modeling efforts (e.g., the USFS NorWeST stream temperature platform). A subset of watersheds within the Snake River, Upper Columbia and Mid-Columbia ESUs will continue to implement regional habitat data collection to support existing long-term habitat monitoring efforts. Consistent with the 2018 proposed action, the Action Agencies will continue to support fish status and trend monitoring for one population per major population group (MPG) for the following life stages: returning adult fish (e.g., PIT arrays in fish ladders, tributary PIT arrays and weirs, redd surveys for Chinook), smolt outmigration abundance and condition (e.g., screw traps), and smolt movement and survival (e.g., PIT tagging and associated arrays). Additional monitoring for habitat or fish status and trends will be evaluated through the development of the forthcoming Columbia River Basin habitat RM&E strategy. The Action Agencies will leverage existing efforts capturing habitat or fish status and trends information funded by regional partners and entities wherever possible to address additional or unmet needs.

Implementation and compliance monitoring

To ensure habitat improvement actions are implemented as planned (e.g., meeting construction design and environmental compliance requirements), the Action Agencies fund ongoing implementation and compliance monitoring (I&C) for completed habitat actions. Generally, I&C monitoring data are used to inform Action Agency habitat program management and can also be used to support science-based analytical tools employed by NOAA Fisheries such as life cycle modeling.

Effectiveness monitoring

The Action Agencies will support effectiveness monitoring related to their habitat mitigation efforts at a range of scales including the site and watershed scales. This monitoring serves multiple purposes, including determining if habitat actions are meeting their physical and/or biological objectives (limiting conditions and relative abundance in ESA-listed species), as well as revealing the benefit of actions on larger scales. To date, many key management questions have been addressed through a variety of

Action Agency, NOAA Fisheries and regional effectiveness monitoring efforts including site-scale programmatic monitoring intensively monitored watersheds (IMWs).

Site-scale effectiveness monitoring

Bonneville will continue to fund site and project-scale action effectiveness monitoring (AEM) through completion of this programmatic project study design in 2023 to provide a comprehensive, consistent, efficient, and cost effective approach to monitor and evaluate the Action Agencies' salmon and steelhead tributary habitat improvement actions (e.g. fish passage, instream wood structures, floodplain enhancement and riparian improvement). The majority of Bonneville's implementation partners conduct site-scale effectiveness monitoring through the AEM Programmatic, including multiple habitat actions distributed across the Snake River, Upper Columbia and Middle Columbia ESUs/distinct population segments (DPSs). Results from this work are available on a rolling basis as action categories monitored in the AEM program are completed and evaluated.

Watershed scale effectiveness monitoring

The Action Agencies will support the completion of summary analysis and synthesis report for the Columbia Habitat Monitoring Program to guide management decisions on habitat priorities funded by Bonneville. The Action Agencies will continue to support fish status and trend monitoring within the Entiat, Lemhi, and John Day basins, all of which were identified as pilot IMWs in the 2008 BiOp. These monitoring results will be made available to inform future effectiveness monitoring called for in the Columbia River Basin tributary habitat RM&E strategy.

The Action Agencies will continue to support ongoing habitat monitoring for a subset of readily available and high value habitat variables, including stream temperature and flow. The results of this monitoring will be evaluated for integration into regional data display platforms through collaborative efforts with regional experts, including the USFS Rocky Mountain Research NorWeST team. Bonneville will continue to fund the development of stream habitat linear networks to display habitat attributes (e.g., stream temperature and flow) in GIS-based data displays and maps in select priority watersheds. Additionally, biologically based fish metrics (e.g., salmon densities) are being explored for use in conjunction with stream habitat metrics to help guide future habitat improvement efforts.

Results of site and watershed-scale effectiveness monitoring will continue to be used to guide future habitat action implementation to ensure the Action Agencies are investing in effective habitat improvement actions designed to help address uncertainty related to any residual adverse effects of CRS management. Additionally, results will be used to help evaluate improvements in habitat and fish status resulting from completed habitat actions in the Columbia River Basin through coordination with the THSC, the Science Committee, and evaluation in regional science-based processes such as life cycle modeling. The development of the regional habitat RM&E strategy will include considerations and recommendations for future effectiveness monitoring.

Research

The Action Agencies recognize the value of focused, cost-effective, time-bound research and validation monitoring that increases our understanding of the cause and effect relationships between habitat

actions and biological fish responses. The forthcoming habitat RM&E strategy will include recommendations for future research priorities consistent with regional critical uncertainties (e.g. Independent Scientific Advisory Board [ISAB] Critical Uncertainties report and the Council's FWP Research Plan). In collaboration with NOAA and when necessary to inform management decisions, the Action Agencies will fund fish and habitat research projects with regional partners as priorities and Action Agency funding availability allows.

Adaptive Management/Decision Support

The THSC will act in a consensus manner to adapt the Tributary Habitat Improvement Program. The THSC will also facilitate improved communication and information transfer between basins, for example, between the RME program and the implementation program, between the Science Committee and habitat practitioners, and from executive decision makers to the field and vice versa. The improved information transfer will help successes and lessons learned move between basins and practitioners faster and better.

High-quality planning and prioritization efforts in sub-basins and MPG's such as the Upper Salmon IRA/MRA process and the Grande Ronde Atlas Process are also a part of the adaptive management process and will be updated periodically.

Adaptive Management of Program Performance Metrics

The Action Agencies have identified metrics for habitat improvement action types at the MPG level for the time frame of this Proposed Action. These metrics become more uncertain the farther into the future they reach. For example, the Action Agencies can predict with relative certainty the actions to be implemented in the first 5 years of this Proposed Action. Forecasting farther into the future becomes less certain because of the complexity of working mostly on private lands. While the Action Agencies can assert that metrics identified at the MPG level (or their equivalent) can be implemented during the course of the Proposed Action, we cannot identify with certainty exactly which actions in which locations will occur.

The Life Cycle Models will provide a valued resource in evaluating potential suites of actions and scenarios to an "envelope" approach of possible conservation actions that will allow the THSC to adjust restoration actions as well as reporting and performance metrics in periods two and three. The THSC will use this analysis to adaptively manage the program approach.

ESTUARY HABITAT

The Action Agencies propose to continue implementing the Columbia Estuary Ecosystem Restoration Program (CEERP) to reduce uncertainty related to the residual effects of the Proposed Action on listed salmon and steelhead migrating through the CRS, including uncertainty regarding climate variability. Since 2007, CEERP has developed and evolved to identify and prioritize the most effective actions in the most strategic locations throughout the estuary. Today, the program has accomplished 64 projects resulting in over 8,500 acres of reconnected floodplains and 390 miles of restored channel networks. The Action Agencies' estuary program has a defined logic path: objective, supporting science, strategies, priorities, and actions (Figure 2-25).

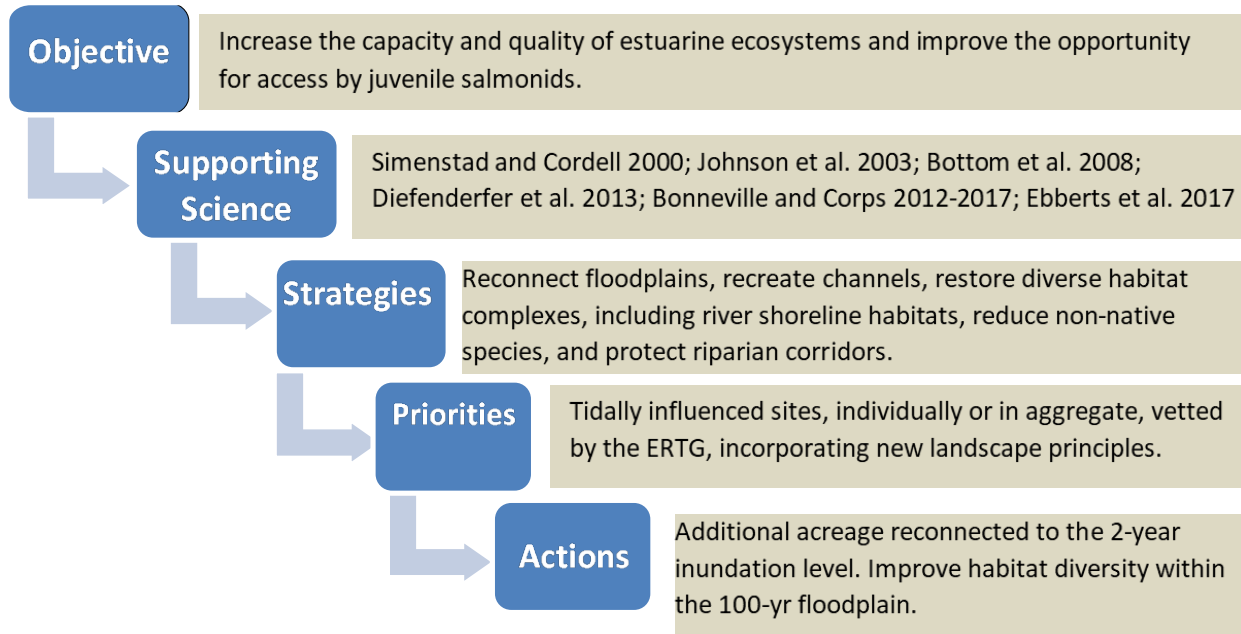


Figure 2-25. Overview of approach to implementing estuary habitat actions

Objective

The Action Agencies will implement the CEERP (Bonneville and Corps 2012, 2016, 2017), to increase the capacity and quality of estuarine ecosystems and improve the opportunity for juvenile salmonids to access these habitats. The estuary is the final stretch of the Columbia River, where all outmigrating juvenile salmon and steelhead species are affected by the transition from freshwater to ocean conditions. Increasing the accessibility, capacity, and quality of estuarine ecosystems provides the final opportunity for juvenile salmon to grow and improve their condition before entering the ocean.

Supporting Science

It has been well documented that subyearling Chinook and to some extent chum salmon (Bottom et al. 2005; Sather et al. 2017) rear and grow in the estuary. Yearling juvenile salmon and steelhead, which spend less time in the estuary than subyearlings, have also demonstrated benefit from time spent in the estuary (Weitkamp et al. 2017). The primary hypothesis driving estuary habitat improvement is that these actions will improve fish habitat and ultimately the growth and fitness of all salmonids, including interior Columbia River Basin-listed salmon and steelhead, as they move from Bonneville Dam to the ocean (McNatt and Hinton 2017; Weitkamp et al. 2017). The results of an evidence-based approach, which evaluated seven lines of evidence, tested and confirmed this hypothesis (Diefenderfer et al. 2016). That is, CEERP is having a cumulative beneficial effect on juvenile salmon. Diefenderfer et al. (2016) also discuss how opposing forces, outside of the Action Agencies' control, such as increased urbanization, industrial development, and loss of forest cover, can negatively affect such efforts and make it challenging to quantify the cumulative effects of these actions. Employing an ecosystem-based approach to habitat improvement actions remains paramount to ensuring projects can adapt to a dynamic environment (Johnson et al. 2003).

Strategies

The Expert Regional Technical Group (ERTG) leverages the best available science and expertise in fish and estuarine improvement ecology to evaluate project proposals (Krueger et al. 2017). ERTG continues to work with the Action Agencies and NOAA Fisheries to focus on the key areas and actions for continued estuarine habitat improvement (ERTG 2012, 2019). Adopted from NOAA Fisheries' estuary module, key actions include reconnecting floodplains, recreating channels, restoring diverse habitat forms, controlling non-native vegetation, and protecting riparian corridors (NMFS 2011). The evidence-based evaluation referred to above found links between these actions and direct and indirect benefits to fish. For instance, actions to reconnect floodplains, such as removing tide gates and breaching levees, eliminate or minimize the physical barriers that disconnect historical floodplain habitat—allowing migrating fish to access the habitat directly. Recreating or reconnecting channels establishes conduits for fish entering the site and for nutrients, macro-detritus, and invertebrate prey to be exported from the site. Prey export provides a mechanism for yearling Chinook salmon and steelhead in the mainstem to benefit from improvement actions without directly accessing the reconnected habitat (Johnson et al. 2018). Reducing non-native species and subsequent native revegetation increases habitat diversity, while supporting the production of preferred salmon prey in the estuary (Bollens et al. 2016). Since 2018, the ERTG has developed a landscape framework to guide future restoration practitioners on geographic distribution, size, and optimal distance between restoration sites to restore ecological functions for salmonids (ERTG 2019). This “stepping stone” approach introduces new actions that are being investigated for future application, including beach nourishment, building and restoring matrix habitat, and beneficial use of dredge material. Since 2008, the Action Agencies has identified the appropriate actions and implemented them across more than 64 sites throughout the estuary (Johnson et al. 2018).

Priorities

The Action Agencies propose to continue refining the CEERP toward increasing habitat opportunities and capacity for juvenile salmonids in the tidally influenced waters of the lower Columbia River and estuary. The ERTG will periodically review completed projects, both at the individual and landscape scale. While the ERTG continues to advise 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), they will also assist the Action Agencies in developing project prioritization criteria, (i.e., where will we get the greatest benefit?). The ERTG, Action Agencies, and NOAA Fisheries will continue to meet monthly in accordance with the CEERP's adaptive management framework to further apply landscape principles and guide project selection and development, including project location and size.

Actions and Metrics

To further inform ERTG's application of landscape principles, the Action Agencies continue to forecast and evaluate the viability and value of future estuary restoration actions. This allows the ERTG to test the application of landscape principles and potentially rank those actions. By having a solid foundation of a scientifically valid process for evaluating the effects of those actions, the CEERP will demonstrate

progress in estuary habitat improvement implementation by reporting the additional acres of floodplain reconnected (inundation at the 2-year flood elevation) (Krueger et al. 2017).

The estuary program continues to use valuable lessons learned regarding the amount of time and effort required to accomplish effective habitat improvement projects, as well as a better understanding of constraints that may render a project site infeasible. In addition to providing bookends for the ERTG to consider what is restorable and how those actions might be relatively ranked, forecasting can also estimate the acreage restorable on a periodic basis. From 2008–2019, the estuary program has accomplished 64 projects, reconnecting, on average, 300 acres per year of floodplain habitat. During the shorter 2019 BiOp period, the Action Agencies were confident that they could meet that annual average based on the projects that were already under development. Given the longer duration of this consultation and the highly variable nature of habitat restoration work where delays or cancellations may only be discovered years into the project development phase, there is greater challenge in forecasting, over an extended time period, an accurate amount of floodplain acreage that can be reconnected annually to the Columbia River's tidal regime.

The Action Agencies propose to establish a 5-year rolling review period during which they and NMFS evaluate both the acreage restored to date, and the increase in restored acreage that is most likely to be accomplished in the following 5 years in the estuary, to determine an annual acreage goal. This evaluation process can be incorporated into the already existing annual update to the CEERP restoration and monitoring plan (BPA and USACE 2019). Considering both the projects that are currently in development and an evaluation of restorable opportunities in the estuary, the Action Agencies have identified a number of projects that have varying degrees of viability. Based on these projects, the Action Agencies believe that restoring an annual average of 300 acres is a reasonable target for the initial 10 years of this consultation. After the first 5 years of this consultation, NOAA Fisheries and the Action Agencies will evaluate the cumulative effectiveness of these and past projects in the estuary, and evaluate additional opportunities and needs.

Monitoring and Evaluation

As noted in the 2018 Proposed Action, the M&E efforts of the Action Agencies' CEERP have standardized and hierarchically organized the intensity of monitoring across sites. These actions assure a statistically sound sampling plan to inform adaptive management at the site and landscape levels (Johnson et al. 2014). This programmatic action-effectiveness monitoring and research (AEMR) plan builds on prior studies conducted over the past 10+ years (e.g., Johnson et al. 2008; Roegner et al. 2009; Diefenderfer et al. 2011; Johnson et al. 2012; Sather et al. 2013). The estuary program annually updates its monitoring strategy based on study results and program uncertainties (Bonnevillie and Corps 2017b).

With an institutionalized adaptive management framework, the CEERP will continue to provide forums in which to revisit the habitat improvement actions and pair them with the AEMR results to date, to facilitate a discussion between practitioners, ERTG, and the Action Agencies (Ebberts et al. 2018). These efforts will continually evaluate the effectiveness of habitat restoration and inform any necessary adjustments to the current habitat restoration and monitoring strategies.

The three levels of AEMR range from intensive to extensive:

Level 1, “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. 2009).

Level 3, “standard AEMR,” monitors key controlling factors and other indicators, e.g., photo points, water surface elevation, and salinity.

The Action Agencies consistently coordinate with NOAA Fisheries, ERTG, and resource practitioners to discuss the appropriate level of monitoring for a given site and for addressing critical or new uncertainties. Projects eligible for monitoring are evaluated annually across a number of environmental and practical variables. The result is a monitoring matrix that identifies the level of monitoring appropriate for each site and a designation of the responsible entity. The matrix is updated as part of the annual update of the estuary program’s habitat restoration and monitoring plans (Bonneville and Corps 2018). This is consistent with how the Action Agencies are implementing the AEMR strategy under past BiOps.

Programmatic Adaptive Management

In addition to ongoing AEMR, the Action Agencies’ CEERP will continue to collaborate with NOAA Fisheries, sponsors, and the ERTG to further refine the approach to restoring estuary habitat. The following efforts are under way to address both current and future uncertainties:

- Synthesis memorandum #2. Every 5 years or so, CEERP re-evaluates the state of the science, the accomplishments to date, and the effects and trends of estuary habitat improvement actions. The latest memorandum was finalized in August 2018 and is currently being evaluated by the Action Agencies, NOAA Fisheries, practitioners, and ERTG.
- ERTG’s landscape perspectives. As noted above, with 64 projects now implemented throughout the estuary, the Action Agencies, NOAA Fisheries, and ERTG continue to consider landscape ecology concepts and principles that can refine and direct where to focus future restoration efforts.
- Uncertainties research. With additional landscape criteria being developed, ERTG will revisit and rank the critical uncertainties that require new or continued attention (ERTG 2011). These recommendations, along with lessons learned and key findings from the Action Agencies RM&E program, will guide future research objectives and study designs.

The collaborative opportunities for the Action Agencies, NOAA Fisheries, restoration and research practitioners, and other stakeholders interested in improving estuary habitats are captured in the adaptive management framework of CEERP (Ebberts et al. 2018). The goal of CEERP adaptive management is to continually assess and improve our understanding and effectiveness of habitat improvement in the estuary.

Climate Variability Considerations

The Actions Agencies' approach to habitat improvement in the estuary incorporates climate considerations during project prioritization, design, and evaluation. The ERTG process emphasizes landscape ecology principles and provides guidance to restoration practitioners. Factors considered include habitat complexity, connectivity, and capacity for self-maintenance. These same factors increase the overall resiliency of a habitat improvement project relative to climate variability stressors, most notably temperature increase and sea level rise. Improving floodplain and stream flow connectivity have recently been documented as some of the most effective actions for counteracting the effects of temperature increase (Beechie et al. 2013). This provides further support for CEERP's emphasis on reconnecting historical floodplain.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss relevant climate science with ERTG and regional partners. The Action Agencies will evaluate future estuary projects for resiliency in the face of climate change (i.e., sea level rise, increasing temperatures, and changes to mainstem flow levels). The Action Agencies annual update of both restoration and monitoring plans in the estuary will document any adjustments necessary, such as changes in design or location, that would help make the project more resilient to climate change impacts, both during the period covered by this consultation and beyond.

2.6.2 Conservation Measures for Kootenai River White Sturgeon

As part of the Proposed Action, Bonneville 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. Habitat and nutrient enhancement actions are currently planned through 2025, and Bonneville expects to fund them, pending additional environmental (e.g., NEPA and ESA) and feasibility reviews. Funding of conservation measures for Kootenai River white sturgeon after 2025 will be subject to Bonneville's prioritization of available funds; investments in fish and wildlife by Bonneville for protection, mitigation and enhancement will be prioritized based on biological and cost-effectiveness and their connection to mitigating for the impacts of the CRS.

2.6.2.1 Conservation Aquaculture

As part of the proposed action, Bonneville will provide funding in accordance with the terms outlined in the Memorandum of Agreement (MOA) between Bonneville and the KTOI for the KTOI's Kootenai River Native Fish Conservation Aquaculture Program for sturgeon (BPA and KTOI 2013). The conservation aquaculture program incorporates both short- and long-term objectives. The production strategy is determined annually based on M&E and is coordinated with regional partners. Short-term objectives are necessary to prevent extinction, and the longer-term objectives are necessary to re-establish a self-sustaining population.

Additionally, Bonneville completed Section 7 ESA consultation with USFWS for funding the aquaculture program. USFWS issued a BiOp (USFWS 2013) evaluating Bonneville's funding and KTOI's Section 10(a)(1)(A) permit for the operation of the aquaculture program. The terms and conditions of the aquaculture program BiOp are incorporated by reference only, and are not included in this consultation. Therefore, the effects of operating and managing that hatchery program to ESA-listed species are considered part of the environmental baseline and will not be evaluated further in subsequent sections of this biological assessment.

2.6.2.2 Habitat Improvement Actions

LIMITING FACTORS AND RESTORATION STRATEGIES

As part of the Proposed Action, Bonneville will continue to implement habitat actions in the Kootenai River to benefit Kootenai River white sturgeon. Restoration actions over the last decade have addressed limiting factors in three major reaches of the Kootenai River: the Braided Reach, Straight Reach, and Meander Reach. The Braided Reach extends approximately 6.2 river miles (RM) (from approximately RM 160.9 to RM 152.7) from the Moyie River confluence downstream to the U.S. Highway 95 Bridge (Figure 2-26). This reach includes the upstream extent of the backwater influence from Kootenay Lake. The Straight Reach extends 1.1 river miles (from approximately RM 152.7 to RM 151.7) from the U.S. Highway 95 Bridge downstream to Ambush Rock. The Meander Reach extends from the downstream end of Ambush Rock to Kootenay Lake at the international border (from approximately RM 151.7 to RM 105.9). The federally designated sturgeon critical habitat, as revised in 2008, includes a portion of the Braided Reach, the entirety of the Straight Reach, and the upstream portion of the Meander Reach. The critical habitat spans 18.3 RM from upstream of Bonners Ferry (RM 159.7) downstream to below Shorty's Island (RM 141.4) (KTOI 2009).

Reach-specific restoration strategies help guide identification and development of site-specific habitat restoration actions. Between 2011 and 2018, the Kootenai Tribe completed construction of 10 Kootenai River habitat restoration projects funded by Bonneville, 8 within the Braided Reach and 2 within the Meander Reach focused on substrate enhancement. Treatments included excavation or enhancement of deep pools in the Braided Reach of the Kootenai River, pool-forming and side-channel structures, construction/reconnection of floodplain habitat (bank grading, islands, point bars), floodplain planting and seeding, and fencing.

BRAIDED REACH RESTORATION STRATEGY

The restoration strategy in the Braided Reach focused on establishing channel dimensions that are sustainable given the morphological setting and governing flow and sediment regimes, reducing sediment supply from major sites of bank erosion, promoting deposition of sediment on the floodplain, constructing a new floodplain that is connected to the channel during average annual peak flows, and revegetating the floodplain in a way that results in a complex, multi-structured native plant community that has a mosaic of age classes and hydrologic regimes.

The Braided Reach enhancement actions have created floodplain, reduced erosion, and established a chain of large, deep pools to create a more pronounced thalweg. These actions have increased staging

and holding habitat to facilitate upstream migration of spawning sturgeon. Pool-forming structures were constructed to maintain pools through scour, while simultaneously creating recirculation zones for holding and feeding habitat used by focal aquatic species. Environmental processes that would naturally occur to form instream habitat attributes for focal species are currently not functioning within the Braided Reach. Over the long term, as riparian and wetland plant communities develop on the created floodplain and along the enhanced streambanks, natural processes may result in the recruitment of large coarse wood being deposited into the stream channel. These long-term occurrences provide attributes for future habitat complexity such as debris jams, scour logs, and the sustainment of pools that increase desired hydraulic components.

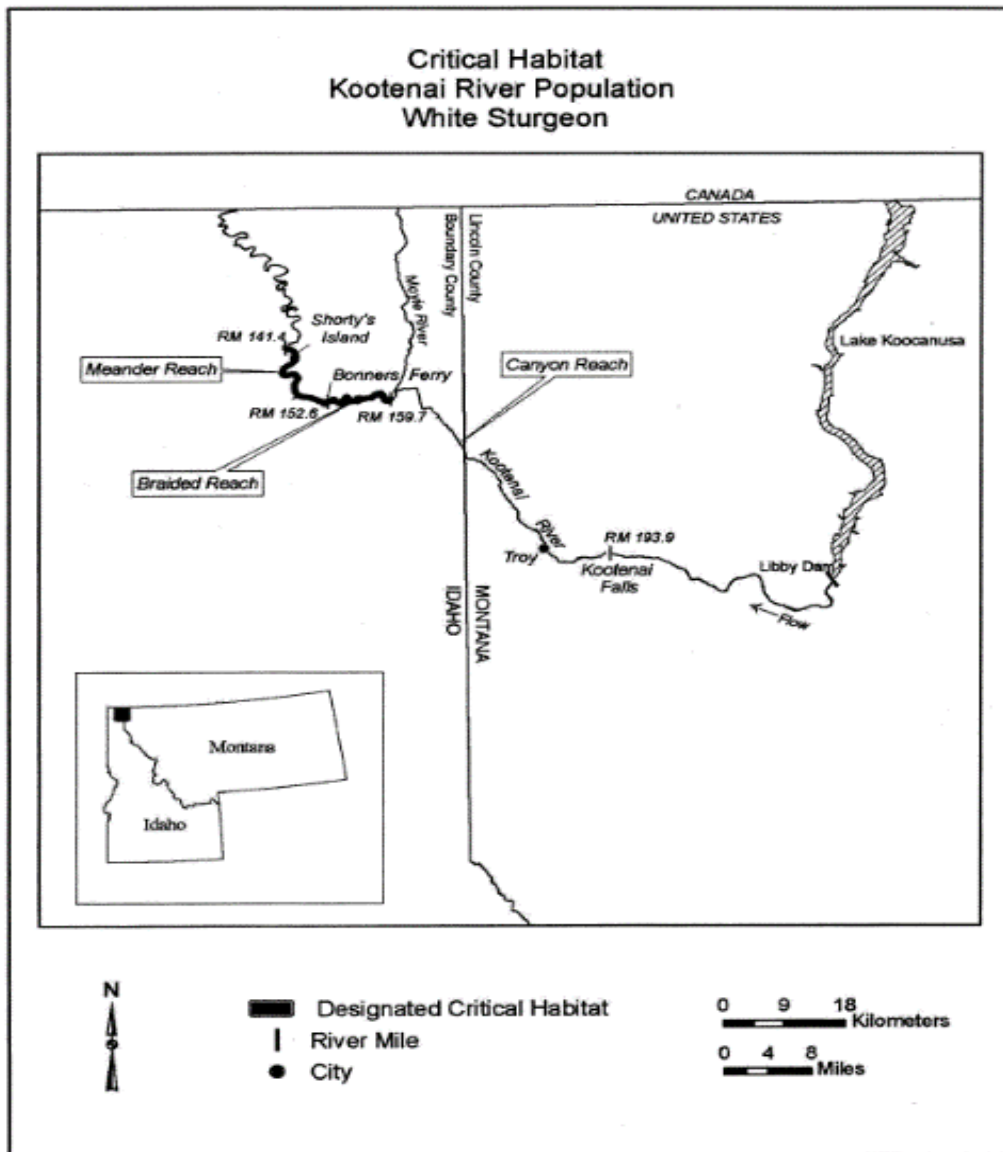


Figure 2-26. Kootenai River white sturgeon critical habitat and river reaches

STRAIGHT REACH RESTORATION STRATEGY

The restoration strategy in the Straight Reach has focused on improving aquatic habitat by increasing cover, pool habitat, and hydraulic complexity and establishing a riparian buffer along the channel margins where possible. The lack of hydraulic complexity has been addressed by installing structures to enhance pools for holding habitat and establish recirculation eddies for refuge and feeding. Higher-velocity habitat suitable for spawning was increased and rocky substrate clusters were installed adjacent to higher-velocity zones in areas of known spawning preference to improve habitat conditions for sturgeon egg deposition and early-life-stage survival. The strategy in the Straight Reach also includes protecting suitable existing habitat.

MEANDER REACH RESTORATION STRATEGY

The Meander Reach is the longest stretch of the Kootenai River in Idaho. Depending on the specific location within the Meander Reach, a number of different restoration strategies are being developed. In general, the Meander Reach restoration strategy focuses on improving interaction between the river and floodplain, both to enhance aquatic habitat and to promote natural nutrient exchange to enhance the food web. Components of the larger Meander Reach restoration strategy being planned include the following:

- placement of instream and bank structures to improve habitat conditions and reduce bank erosion,
- supplementation of outer bends with woody debris structures to create hiding cover for some aquatic focal species,
- placement of woody debris near tributary mouths to improve instream habitat at these confluences,
- excavation of floodplain surfaces in areas adjacent to the channel where levees are located some distance from the river (areas that could be excavated without compromising FRM infrastructure functionality),
- connection of floodplain that is currently below peak flow river stage to create off-channel habitat,
- removal of fish barriers to tributaries within the floodplain, and
- restoration of aquatic and riparian habitat along tributary streams.

Implementation of restoration actions at each potential improvement site depends on technical feasibility, development of a specific project design, cooperation of local landowners and other entities, funding availability, and completion of project-specific environmental compliance and permitting. Information gathered through M&E associated with the previous habitat restoration activities is used to inform selection, design, and implementation of future restoration actions.

POTENTIAL HABITAT ACTIONS – 2021 THROUGH 2025

Over the last decade, the Action Agencies have implemented most of the habitat actions recommended by the USFWS in their 2006 Libby BiOp and 2008 clarifications. The federal agency biologists expect that habitat actions implemented to date, combined with nutrient additions and improvements to Libby operations, have substantially improved spawning and rearing conditions for sturgeon. It will take time for the benefits of these past habitat improvement actions to be fully realized, because the sturgeon that are expected to benefit from these actions in more significant numbers have not yet reached sexual maturity. Early data indicate there is some positive sturgeon response to these actions, which suggests a trend in the right direction.

Against the backdrop of these improvements in the environmental baseline, the Action Agencies, in coordination with the USFWS and regional implementation partners, have determined that a continuation of recent efforts is warranted for the first 5 years of the period covered by this consultation. Therefore, the Action Agencies will work with implementation partners, including the KTOI, IDFG, and existing advisory teams (e.g., Co-manager Advisory Team and Peer Review Advisory Team), to identify and prioritize additional restoration opportunities in the Braided Reach and Meander Reach. 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.

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 (2021–2025) of this action to benefit Kootenai River white sturgeon. The Action Agencies expect 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. 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. 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.

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. Further discussion of this adaptive approach following the initial 5-year implementation commitment is discussed in the “Adaptive Management” subsection below.

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 BiOp for the program (FWS Ref: 01EIFW00-2013-F-0278).

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.

To assure 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. Large cottonwood plantings and wetland riparian revegetation discussed in the CRSO EIS are considered part of the Kootenai River white sturgeon (KRWS) Tier 1 actions for floodplain restoration and enhancement.

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 Categories

Supplemental Spawning Gravels

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

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 2021–2025. 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 assure 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 drive 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 Appendix D Tributary Habitat, p.24.

2.6.2.3 Nutrient Additions

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.

KOOTENAI RIVER NUTRIENT ADDITION

To mitigate the reduced nutrient availability and associated biological productivity, the International Kootenai Ecosystem Recovery Team recommended a 5-year experimental nutrient restoration effort in the Kootenai River in 2003; the experiment was initiated in 2005. 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. From 2006 to 2013, the nutrient additions occurred between June 1 and September 30 (Hoyle et al. 2014). Nutrient addition since 2013 now 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 RM&E is an important part of the project and are used to monitor and adaptively manage the nutrient addition project. The RM&E component of the project collects water quality and algal, macroinvertebrate, and fish data. This includes data from several years before and after the experimental nutrient addition. 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, Bonneville proposes to continue funding this action through fiscal year 2025 and will continue to use RM&E results to inform future management decisions.

KOOTENAY LAKE NUTRIENT ADDITION

Beginning in 2004, based on the International Kootenai Ecosystem Recovery Team's recommendation, Bonneville provided funding for the British Columbia (B.C.) Ministry of Environment (now the B.C. Ministry of Forests, Lands and Natural Resource Operations, or BCMFLNRO) to conduct experimental annual additions of nutrients in the South Arm of Kootenay Lake and associated monitoring. Both the South Arm of Kootenay Lake and Kootenai River actions were funded by Bonneville and managed and monitored through the Kootenai River Ecosystem Restoration Project.

Since 1992, British Columbia has operated a successful ongoing program of adding nutrients to the North Arm of Kootenay Lake, where impacts are more directly associated with Duncan Dam, to increase biological productivity and restore native fish populations. Beginning in 2003, Bonneville funded monitoring and limnologic research in the South Arm of Kootenay Lake, which confirmed suspicions that nutrient levels in the lake were likely limiting food web and fisheries development. This situation was exacerbated by a Mysid shrimp invasion, which further reduced zooplankton abundance, which in turn affected the density of kokanee salmon, an important food item for adult and juvenile sturgeon. 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 nitrification 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 BCMFLNRO, with Bonneville funding provided through the Kootenai River Ecosystem Restoration Project.

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, Bonneville proposes to continue funding this action through fiscal year 2025 and will continue to use RM&E results to inform management decisions regarding future actions.

2.6.2.4 Monitoring and Evaluation for Kootenai River White Sturgeon

M&E funded by Bonneville is 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 KRWS 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, and
- monitoring of existing (constructed) habitat structures to assure 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 (KTOI 2005). 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 upon 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 Bonneville's overall adaptive management approach. These M&E studies are subject to modification based on the new scientific information, project results, or other factors Bonneville 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, Bonneville 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 to the suite of Bonneville-funded conservation actions for Kootenai River white sturgeon.

2.6.3 Conservation Measures for Bull Trout

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

2.6.3.1 Albeni Falls Actions to Benefit Bull Trout

The Corps, in coordination with Bonneville, 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 BiOp to the Corps on the construction, operation, and maintenance of an upstream fish passage facility at Albeni Falls Dam (FWS Ref: 01EIFW00-F-0259). 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 on continuing coordination with federal, state, and tribal agencies throughout this process.

2.6.3.2 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, 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 benefitting upstream passage opportunities over the period of 2021–2026. Any additional improvement opportunities to benefit bull trout passage in Kootenai River tributaries will be evaluated based on biological priorities and available funding.

2.6.3.3 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. See Section 2.4.7.4 for proposed non-routine maintenance measures (including new IFP turbines at Ice Harbor, McNary and John Day dams) and Section 2.6.1.1 for proposed structural measures.

2.6.3.4 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 in Section 2.7.1 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, per the schedule provided in Table 2-21. 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, gas bubble trauma [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 Bonneville-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 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 state of knowledge advances. Action Agencies will continue to emphasize monitoring that fulfills mitigation requirements and directly informs management needs.

2.6.3.5 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 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.

2.6.3.6 Tributary Habitat Improvements for Bull Trout

As described in Section 2.6.1, 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.

2.6.3.7 Spawning Habitat Augmentation at Lake Roosevelt

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 resident species, such as kokanee, which is an important forage fish for ESA listed bull trout. In 2019, Bonneville funded year one of a three year study to determine if modifications in Lake Roosevelt refill would impact resident fish access to spawning habitat and success. If the results indicate that resident fish spawning habitat is impacted by the operation, the Action Agencies will supplement spawning habitat at locations up to 100 acres along reservoir and tributaries.

2.6.4 Adaptive Management and Contingency Actions

The Action Agencies propose to continue to utilize adaptive management principles in implementing the Proposed Action. 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.

It is the Action Agencies' understanding that NOAA Fisheries plans to continue monitoring species status. If the ESA-listed anadromous salmon and steelhead species reach a threshold of concern or substantial departures from current trends are detected, the Action Agencies will work with federal, state and tribal sovereigns and other appropriate parties in any region-wide diagnostic efforts to determine the causes of significant declines in the abundance of naturally produced salmon and steelhead. The Action Agencies anticipate that all relevant partners working on ESA-listed salmon and steelhead within the Columbia River Basin would participate in these conversations because the choice of appropriate response to species declines will depend upon the immediate limiting factor(s) diagnostics and may or may not solely be related to or addressed by the Action Agencies' management of the Columbia River System. In-season and annual changes will be adaptively managed through established Regional Forum (see Section 2.1, Regional Coordination for details).

In past biological opinions several contingency actions were identified to respond to declining fish abundance including increased predator controls, certain harvest controls, safety net hatcheries, modified hydrosystem operations, etc.

The Action Agencies will continue to work with NOAA Fisheries and USFWS to identify and operationalize potential contingency actions should the need arise. Some examples of contingency actions that Action Agencies could make readily available as needed, depending on the species include:

1. Modification to the Fish Transportation program: If diagnostics indicate this action could be potentially effective, a process could be initiated in coordination with the Regional Forum (e.g., FPOM coordination team, TMT, etc.).
2. Safety net programs: The Action Agencies could discuss with hatchery operators potential reprogramming of certain hatchery programs to safety-net hatchery programs to address declining status issues.
3. Kelt Reconditioning: In years of low steelhead returns, reconditioned kelts can help to boost abundance of steelhead on the spawning grounds. The Action Agencies could make this program available as a contingency measure should steelhead numbers show significant declines.

By using the established Regional Forum (Figure 2-1) and having potential contingency actions at the ready, the Action Agencies will routinely and predictably collaborate with the regional experts, while adapting to new information and responding to unanticipated outcomes or challenges that may arise as a result of implementing the Proposed Action.

2.7 MONITORING, REPORTING, AND REGIONAL COORDINATION

The Action Agencies use the best available scientific information to identify and carry out actions intended to provide immediate and long-term benefits to ESA-listed fish, while continuing to operate for other authorized project purposes set forth by Congress. To that end, the Action Agencies report to and coordinate with federal, state, and tribal sovereigns and other regional partners. This section describes

these and related activities. Additional monitoring objectives may be covered under certain operational and non-operational conservation measures for fish and wildlife in Sections 2.3.2 and 2.6, respectively.

2.7.1 Fish Monitoring at Lower Columbia and Lower Snake River Dams

Biological performance for system operations will be tracked through ongoing juvenile and adult fish monitoring at the lower Columbia and lower Snake River dams. Annual and in-season monitoring results are used to inform in-season operations decisions and through appropriate regional coordination forums (e.g., the TMT and FPOM groups), identify potential research or evaluation needs (see Section 2.7.2), and inform longer-term management decisions regarding system operations.

2.7.1.1 Juvenile Fish Monitoring

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

- Continue to annually fund and implement the SMP. Program objectives will continue to include monitoring, evaluation, and reporting on abundance and migration timing of juvenile anadromous salmonids passing index dams, smolt condition (e.g., descaling, injury, GBT) at all dams that have JBSs, and identification of potential problems (e.g., debris accumulation) to inform in-season management actions. Additional SMP objectives will include the following:
 - Determine whether additional biological monitoring or sampling at juvenile bypass facilities is warranted to assess potential effects of increased TDG as a result of increased spring spill operations. (See Section 2.7.2.1 below for additional spill-related evaluation actions.)
 - Continue to collect information on bull trout collected in SMP samples or observed elsewhere in JBSs. (For a complete list of bull trout monitoring actions, see Section 2.6.3.4 above.)
 - Identification and condition (e.g., injury) of Pacific lamprey collected in SMP samples.
- Continue to implement and maintain the Columbia River Basin Passive Integrated Transponder Information System (PTAGIS). The Action Agencies anticipate that NMFS will use PIT data to annually estimate travel times and survival rates for in-river migrating juvenile salmonids.
- Implement improvements to PIT detection capability to support NMFS' ongoing annual development of in-river juvenile salmon and steelhead survival estimates. Specifically, the Action Agencies will continue to investigate and implement, if warranted, PIT detection improvements at or near Bonneville Dam.

2.7.1.2 Adult Fish Passage Monitoring

To monitor adult fish migration through the CRS, the Action Agencies will do the following:

- Visually count adult salmon, steelhead, and bull trout passing lower Columbia and lower Snake River dams, per the schedule provided in Table 2-21 (see Section 2.6.3.4 above for additional bull trout monitoring actions).

- Continue to maintain PIT detection capability in adult fishways at the lower Columbia and lower Snake River dams as needed to support monitoring of adult salmon and steelhead survival through the CRS and monitoring of PIT-based fishway re-ascension rates to identify any potential passage delay or fallback issues. The Action Agencies will maintain PIT detection capability to allow NMFS to (1) monitor adult salmon and steelhead survival through the CRS to confirm that the relatively high levels of adult survival currently observed are maintained, and (2) compare the survival rates of different stocks. Adult fishway PIT detection arrays will also continue to be used to monitor PIT-tagged bull trout presence in fishways and JBSs. Detection information will continue to be made available via the PTAGIS website.
- In coordination with NMFS, USFWS, and other regional sovereigns, the Action Agencies will monitor adult ladder counts and PIT-based re-ascension rates to identify any potential delay or fallback issues that may be associated with proposed CRS operations or delays that may be associated with temperatures in the exit sections of fishways (see Section 2.6.1.1 above). Any potential changes in operations or configurations would be coordinated with federal, state, and tribal sovereigns through the appropriate Regional Forum work group (e.g., FPOM).
- Monitor pinniped activity at Bonneville Dam, consistent with the monitoring plan to be developed in coordination with NMFS, as described in Section 2.6.1.3.

2.7.1.3 Salmon and Steelhead Status Monitoring

The Action Agencies will support the following monitoring activities designed to effectively track the status of ESA-listed species affected by Action Agency actions:

- Continue Action Agency funded fish population status and trend monitoring of adults and juveniles in support of population viability assessments and life-cycle models in order of priority
- Continue juvenile and adult survival monitoring through federal mainstem dams as detailed in Section 2.7.1
 - SR sockeye
 - Upper Columbia and SR steelhead and Chinook
 - Representative populations of MCR steelhead
- Implement elements of natural origin adult abundance monitoring for the Snake River fall Chinook ESU in cooperation with LSRCP and US v. Oregon and Idaho Power actions.
- Use new and emerging tools, techniques, and methods that assist with status and trend monitoring such as genetics (GSI or SNPs) and tagging for abundance.

Ongoing efforts will continue to improve the Action Agencies' approach to CRS status monitoring (analytical approaches, tagging needs, methods, and protocols), focusing on programmatic efficiencies and improved reporting through technology and elimination of duplication, and to minimize take from monitoring activities. This will be done in collaboration with the state, tribal, and federal fishery agencies and coordinated with other status monitoring needs and strategies for the region.

Ongoing support also includes Bonneville contributions to research involving the effects of nearshore ocean conditions on adult returns.

2.7.2 Research and Evaluation Actions at the CRS Dams

The Action Agencies anticipate that some proposed operations and potential structural modifications will necessitate action-effectiveness evaluations. The Action Agencies will continue to coordinate with NMFS, USFWS, and others through the appropriate regional coordination forums to identify, define, and evaluate other emerging issues not specifically identified below (see Section 2.6.4).

Table 2-21. Adult fish counting schedules for the lower Columbia and lower Snake River dams

Project	Period	Time (PST)	Method
Bonneville	January 1–March 31	0400–2000	Video
	April 1–May 14	0400–2000	Visual
	May 15–September 30	0400–2000 2000–0400	Visual Video
	October 1–November 30	0400–2000	Visual
	December 1–December 31	0400–2000	Video
The Dalles	April 1–June 14	0400–2000	Visual
	June 15–September 30	0400–2000 2000–0400	Visual Video
	October 1–October 31	0400–2000	Visual
John Day	April 1–June 14	0400–2000	Visual
	June 15–September 30	0400–2000 2000–0400	Visual Video
	October 1–October 31	0400–2000	Visual
McNary	April 1–June 14	0400–2000	Visual
	June 15–September 30	0400–2000 2000–0400	Visual Video
	October 1–October 31	0400–2000	Visual
Ice Harbor	April 1–October 31	0400–2000	Visual
Lower Monumental	April 1–October 31	0400–2000	Visual
Little Goose	April 1–October 31	0400–2000	Visual
Lower Granite	March 1–March 31	0400–2000	Video
	April 1–May 31	0400–2000	Visual
	June 1–September 30	0400–2000 2000–0400	Visual Video
	October 1–October 31	0400–2000	Visual
	November 1–December 30	0400–2000	Video

Note: All times are shown in Pacific *Standard* Time. Schedules at Bonneville and Lower Granite Dams do not vary from year to year. At the other six dams, daytime video counts are conducted from March 1 to March 31 and November 1 to February 28/29 at two dams each year, on a rotating basis.

2.7.2.1 Evaluate Biological Effects of Increased Spill

There continues to be substantial uncertainty around the biological effects of increased spill. The Comprehensive Passage (COMPASS) and Comparative Survival Study (CSS) models used in the CRSO EIS analysis suggest a wide range of potential outcomes, ranging from a substantial hypothesized benefit through reduced latent mortality to a negative impact through a reduction in beneficial transport rates. Neither model considers the effect of increased exposure to elevated TDG levels. Neither model assesses the potential unintended consequences for resident aquatic species. Given this uncertainty and the range of potential outcomes, the Action Agencies propose to implement a study (or studies) to test the biological effects of increased spill.

Accordingly, the Action Agencies are working 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, re-ascension). Specific study design elements are being developed collaboratively and may include considerations such as

- spill operations to be studied
- expected power of proposed study or studies to detect an effect
- potential duration of experiment(s)
- the number of fish and the source of fish to be studied in experiment(s)
- an evidence-based decision framework under which to evaluate results
- the means of monitoring potential adverse effects on both juvenile and adult migrants
- the means of assessing potential other factors such as condition of fish selecting various routes of passage
- other topics that may be identified.

The details of study designs, as well as any subsequent adaptive implementation that may be needed if unintended consequences result from high spill levels, are detailed in the Adaptive Implementation Framework.

2.7.2.2 Investigate Shad Deterrence at Lower Granite Dam

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 may include acoustic deterrents and operational changes, such as instituting plunging flows or blocking overflow weirs. If feasible, the Corps will implement operational or small-scale structural measures to address this issue. Any associated evaluations or changes in fishway operations or configurations will be coordinated with the appropriate regional coordination forums (e.g., FPOM).

2.7.2.3 Off-season Surface Spill for Downstream Passage of Adult Steelhead and Bull Trout

Some Mid-Columbia River (MCR) steelhead migrate upstream past McNary Dam, overshooting tributaries downstream, primarily the John Day and Umatilla Rivers. These fish then migrate back downstream through McNary Dam during months when there is no scheduled juvenile fish passage spill; fallback passage is theorized to peak in September-October and February-March. 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, including bull trout, at McNary Dam. The evaluation will continue in the spring of 2020 and the results will be shared with the Services and other federal, state, and tribal sovereigns through the Regional Forum processes.

- The Corps will continue to refine and implement a multi-year evaluation to determine frequency, timing, and duration and of the off-season surface spill needed to effectively pass adult steelhead and bull trout downstream of McNary Dam. Particular study objectives will continue to be developed and refined with NMFS, USFWS, and other regional sovereigns through the Studies Review Work Group.
- Pending results of the evaluation, the Action Agencies will, in coordination with NMFS, USFWS, and the FPOM, 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 off-season 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 (and bull trout).
- For all actions and studies, steelhead or (in the case of hydroacoustic evaluations) steelhead-sized targets will be used as surrogates for adult bull trout. 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 adult bull trout.

2.7.2.4 Biological Testing of Improved Fish Passage Turbines

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. In this and similar studies, biologists directly release tagged fish into the turbine and recover them in the tailrace. Recovered fish are examined for mortality or injuries and are then held for a 48-hour survival observation. Concurrently, Sensor Fish (artificial fish outfitted with sensors) are released into the turbine unit to validate assumptions about hydraulic conditions in the turbine environment. Study results from the Ice Harbor evaluation are pending and will be used to validate the new turbine design and inform future designs.

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.

2.7.2.5 *Biological Studies to Inform Management Decisions Regarding Potential Cessation of Fish Screen Deployment at Dams Equipped with Improved Fish Passage Turbine Units*

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 (see Section 2.3.3.4). In addition to further coordination with NMFS, USFWS, and other regional sovereigns, the Action Agencies anticipate that any proposed changes in the configurations or operations at these dams may require types of biological monitoring and evaluations. If the study results demonstrate a neutral or beneficial effect, the Action Agencies will consider cessation of turbine intake bypass screen installation.

While specific objectives or metrics have not been developed, the Action Agencies anticipate that acoustic telemetry studies (beginning with Ice Harbor Dam) would be needed to evaluate total dam passage and survival and facilitate comparison with historical survival metrics.

Additionally, the Action Agencies would consider—and may need to conduct biological studies—to assess the effects on adult salmon and steelhead (particularly steelhead kelts and overshoots and bull trout) passage through JBSs, impacts on regional monitoring programs such as the SMP and PIT-based system survival analyses, and impacts on juvenile Pacific lamprey.

Particular study objectives and needs would be developed with NMFS, USFWS, and other regional sovereigns through the Studies Review Work Group.

2.7.2.6 *Adult Salmon and Steelhead Passage and Behavior in Response to Fishway Modifications for Pacific Lamprey*

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 and bull trout. Particular study objectives and needs would be developed with NMFS, USFWS, and other regional sovereigns through the Studies Review Work Group.

2.7.3 Annual BiOp Implementation Reporting

The Action Agencies use the best available scientific information to identify, carry out and report on actions that are expected to provide immediate and long-term benefits to ESA-listed fish. To that end, the Action Agencies will coordinate implementation planning and progress reporting with the USFWS and NMFS to inform and signal appropriate adaptations to changing circumstances. In addition to the information and reports (Table 2-22), the Action Agencies intend to work with the Services during the consultation to further identify information and reporting needs.

Table 2-22. Information available or provided to the Services on Action Agency Implementation

Type	Forum or Group	Information	Location of Information or Report
Operational Conservation Actions			
System Operations & Maintenance	Regional Implementation Oversight Group (RIOG)	Annual Fish Operations Plan (FOP)	<i>TMT Website:</i> http://pweb.crohms.org/tmt/documents/fpp/
	Flex Spill Work Group (FSWG)	<i>Not Applicable</i>	Action Agencies will work with Services to identify appropriate report
	Technical Management Team (TMT)	Annual Water Management Plan	<i>TMT website:</i> http://pweb.crohms.org/tmt/documents/fpp/
	Fish Passage Operation and Maintenance (FPOM)	Annual Fish Passage Plan incl. FOP Weekly Project, Fishway and Fish Activities Memorandums	<i>TMT website:</i> http://pweb.crohms.org/tmt/documents/fpp/ <i>FPOM website:</i> http://pweb.crohms.org/tmt/documents/FPOM/2010/
	Systems Configuration Team (SCT)	Col River Fisheries Mitigation budget	<i>SCT website:</i> http://pweb.crohms.org/tmt/documents/FPOM/2010/SCT/SCT.html
	Fish Facilities Design Review Workgroup (FFDRWG)	Project Design Reports Research Recommendations	<i>FFDRWG website:</i> http://pweb.crohms.org/tmt/documents/FPOM/
	Studies Review Work Group (SRWG)	Research Proposals Research Annual Review (meeting) Research Reports	<i>SRWG:</i> http://pweb.crohms.org/tmt/documents/FPOM/2010/SRWG/SRWG.html

Non-Operational Conservation Actions			
Fish Status Monitoring	Fish Passage Center	Daily & Yearly Dam Counts Smolt to Adult Returns Smolt Migration Timing Smolt Passage Data (PIT) Juvenile Reach Survival	<p><i>Fish Passage Center website:</i> http://www.fpc.org/adultsalmon/adultqueries/Adult_Table_Submit.html</p> <p><i>Fish Passage Center website:</i> http://www.fpc.org/survival/smolttoadult_queries.html</p> <p><i>Fish Passage Center website:</i> http://www.fpc.org/smolt/SMP_queries.html</p> <p><i>Fish Passage Center website:</i> http://www.fpc.org/smolt/smoltPITtag.html</p> <p><i>Fish Passage Center website:</i> http://www.fpc.org/survival/smp_multiyearsurvival_query.html</p>
	Northwest Fisheries Science Center	Smolt Abundance Report	<i>The Action Agencies will work with NMFS to determine where this information will be located during the period of this consultation</i>
	Kootenai River Sturgeon	TBD	<i>The Action Agencies will work with USFWS to identify appropriate report during the consultation</i>
	Bull Trout	TBD	<i>The Action Agencies will work with USFWS to identify the appropriate report during the consultation</i>
Predation Monitoring	Pinniped Task Group	Monthly & Yearly Status Reports	Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace: http://pweb.crohms.org/tmt/documents/FPOM/2010/Task%20Groups/Task%20Group%20Pinnipeds/
	TBD	Northern Pikeminnow Program Annual Report	<i>The Action Agencies will work with the Services to identify the appropriate location for the report during the consultation</i>
	TBD	Avian Predation & Monitoring	<i>The Action Agencies will work with the Services to identify the appropriate reporting framework during the consultation</i>
Habitat Actions	Tributary Habitat Steering Committee	Tributary Habitat annual action implementation progress report	The action agencies will work with NOAA to confirm reporting requirements within the first year of implementing the BiOp.
	Columbia Estuary Ecosystem Restoration Program	Annual Restoration & Monitoring Report	Annually report coordinated with NOAA, sponsors, and Action Agencies. Posted in "Documents" within the Estuary Program section of cbfish.org.

2.8 REFERENCES

- 72 Stat. 563. 1958. *Fish and Wildlife Coordination Act of 1958*. Public Law 85-624. August 12, 1958.
- Beechie T, H Imaki, J Greene, A Wade, H Wu, G Pess, P Roni, J Kimball, J Stanford, P Kiffney and N Mantua. 2013. "Restoring Salmon Habitat for a Changing Climate." *River Research and Applications* 29(8):939-960. DOI: 10.1002/rra.2590.
- Bollens S, G Rollwagen-Bollens, E Dexter, W Hassett, J Adams, A Bowen, J Zimmerman, J Cordell, O Kalata and T Counihan. 2016. "Invasive Species and Plankton Dynamics of the Columbia River Estuary." Presented at *Columbia River Estuary Conference 2016*, May 24-26, 2016, Astoria, OR. Available at https://www.estuarypartnership.org/sites/default/files/resource_files/Bollens_etAl_CREC_2016.pdf.
- Bonneville. 2016. *Guide to Tools and Principles for a Dry Year Strategy*. Portland, OR: Bonneville Power Administration (BPA). Available at <https://www.bpa.gov/p/Generation/Dry-Year/DryYear/Guide-to-Tools-and-Principles-for-a-Dry-Year-Strategy.pdf>.
- Bonneville and Corps. 2012. *Columbia Estuary Ecosystem Restoration Program: 2012 Action Plan. Final Report*. Portland, OR: Bonneville Power Administration (Bonneville) and U.S. Army Corps of Engineers (Corps).
- Bonneville and Corps. 2016. *Columbia Estuary Ecosystem Restoration Program: Final Environmental Assessment*. Portland, OR: Bonneville Power Administration (Bonneville) and U.S. Army Corps of Engineers (Corps). Available at https://www.energy.gov/sites/prod/files/2016/07/f33/EA-2006_FEA-2016.pdf.
- Bonneville and Corps. 2017. *Columbia Estuary Ecosystem Restoration Program: 2017 Restoration and Monitoring Plan*. Portland, OR: Bonneville Power Administration (Bonneville) and U.S. Army Corps of Engineers (Corps). Available at <https://www.cbfish.org/EstuaryAction.mvc/Documents>.
- Bottom DL, CA Simenstad, J Burke, AM Baptista, DA Jay, KK Jones, E Casillas and MH Schiewe. 2005. *Salmon at River's End: The Role of the Estuary In the Decline and Recovery of Columbia River Salmon*. Seattle, WA: U.S. Dept. of Commerce, Northwest Fisheries Science Center. NOAA Technical Memorandum NMFS-MWFSC-68. Available at <https://repository.library.noaa.gov/view/noaa/3432>.
- BPA and KTOI. 2013. *Memorandum of Agreement between the Department of Energy Bonneville Power Administration and the Kootenai Tribe of Idaho for the Kootenai River Native Fish Conservation Program White Sturgeon and Burbot Hatchery Facilities*.
- BPA and USACE. 2019. *Columbia River Ecosystem Restoration Program 2019 Restoration and Monitoring Plan: Final Report*. Bonneville Power Administration and U.S. Army Corps of Engineers. Available at <https://www.cbfish.org/FileResource.mvc/DownloadPdfFileResource/1c0be288-e85e-48e7-a950-3e0d3cbc444e>.
- BPA, USBOR and USACE. 2019. *2020 Water Management Plan*. Portland, OR: Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers.
- Corps. 1999. *Kootenai Flood Control Study Analysis of Local Impacts of the Proposed VARQ Flood Control Plan. Status Report. Work to Date on the Development of the VARQ Flood Control Operation at Libby Dam and Hungry Horse Dam. Section 2*. U.S. Army Corps of Engineers (Corps).
- Corps. 2013. *Final FONSI: Caspian Tern Predation Management in the Lower Columbia River Estuary*. Portland, OR: U.S. Army Corps of Engineers (Corps), Portland District. Available at

<https://www.nwp.usace.army.mil/Media/Public-Notices/Article/492528/final-fonsi-caspian-tern-predation-management-in-the-lower-columbia-river-estua/>.

Corps. 2014. *Inland Avian Predation Management Plan*. Walla Walla, WA: U.S. Army Corps of Engineers (Corps), Walla Walla District, Northwestern Division. Available at <https://www.nwp.usace.army.mil/Missions/Projects/Inland-Avian-Predation-Management-Plan/>.

Corps. 2015a. *Caspian Tern Nesting Habitat Management East Sand Island, Clatsop County, Oregon, Final Environmental Assessment*. Portland, OR: U.S. Army Corps of Engineers (Corps), Portland District, Northwestern Division.

Corps. 2015b. *Caspian Tern Nesting Habitat Management East Sand Island, Clatsop County, Oregon, Finding of No Significant Impact*. Portland, OR: U.S. Army Corps of Engineers (Corps), Portland District, Northwestern Division.

Corps. 2015c. *Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary*. Portland, OR: U.S. Army Corps of Engineers (Corps). Available at https://www.aphis.usda.gov/regulations/pdfs/nepa/OR_DCCO%20FEIS%20ESI%20Feb%206%202015.pdf.

Case 3:01-cv-00640-SI, Document 2298-1. 2018. *2019-2021 Spill Operation Agreement*

Corps, Reclamation and Bonneville. 2017. *Endangered Species Act Federal Columbia River Power System 2016 comprehensive evaluation - section 1*. Portland, OR: U.S. Army Corps of Engineers (Corps) Northwestern Division; Bureau of Reclamation (Reclamation) Pacific Northwest Region; Bonneville Power Administration (Bonneville). Available at <https://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/fcrps-2016-comprehensive-evaluation>.

Diefenderfer HL, AB Borde, IA Sinks, VI Cullinan and SA Zimmerman. 2016. *Columbia Estuary Ecosystem Restoration Program: Restoration Design Challenges for Topographic Mounds, Channel Outlets, and Reed Canarygrass*. PNNL-24676. Richland, WA: Pacific Northwest National Laboratory. Final report prepared for the Bonneville Power Administration, Portland, Oregon by the Pacific Northwest National Laboratory, Sequim, Washington and Columbia Land Trust, Vancouver, Washington.

Diefenderfer HL, RM Thom, GE Johnson, JR Skalski, KA Vogt, BD Ebberts, GC Roegner and EM Dawley. 2011. "A Levels-of-Evidence Approach for Assessing Cumulative Ecosystem Response to Estuary and River Restoration Programs." *Ecological Restoration* 29(1-2):111-132. DOI: 10.3368/er.29.1-2.111.

Ebberts BD, BD Zelinsky, JP Karnezis, CA Studebaker, S Lopez-Johnston, AM Creason, L Krasnow, GE Johnson and RM Thom. 2018. "Estuary Ecosystem Restoration: Implementing and Institutionalizing Adaptive Management." *Restoration Ecology* 26(2):360-369. DOI: 10.1111/rec.12562.

ERTG. 2011. *Guidance on Estuary Module Actions and Subactions Relevant to the ERTG Process*. ERTG 2011-02. Portland, OR: Expert Regional Technical Group (ERTG). Available from Bonneville Power Administration or the U.S. Army Corps of Engineers, Portland, Oregon.

ERTG. 2012. *Guidance on Estuary Module Actions and Subactions Relevant to the ERTG Process*. ERTG 2011-02, Rev. 1. Portland, OR: Expert Regional Technical Group (ERTG). Prepared for the Bonneville Power Administration, U.S. Army Corps of Engineers, and NOAA Fisheries. Portland, Oregon.

ERTG. 2019. *Landscape Principles for CEERP Restoration Strategy*. ERTG 2017-02. Portland, OR: Expert Regional Technical Group (ERTG). Prepared for the Bonneville Power Administration, U.S. Army Corps of Engineers, and NOAA Fisheries. Available at

<https://www.cbfish.org/FileResource.mvc/DownloadPdfFileResource/61203df8-9ba3-4b71-bec9-ee1afc687489>.

Hoffman G, BL Marotz and J Dunnigan. 2002. *Mitigation for the Construction and Operation of Libby Dam, 2000 Annual Report*. DOE/BP-00006294-1. Portland, OR: Montana Fish, Wildlife, and Parks. DOI: 10.2172/807637.

Hoyle GM, C Holderman, PJ Anders, B Shafii and KI Ashley. 2014. "Water Quality, Chlorophyll, and Periphyton Responses to Nutrient Addition in the Kootenai River, Idaho." *Freshwater Science* 33(4):1024-1029. DOI: 10.1086/677883.

Johnson G, C Studebaker, J Doumbia, M Schwartz and C Corbett. 2014. *Columbia Estuary Ecosystem Restoration Program: Programmatic Plan for Action Effectiveness Monitoring and Research (Final Report)*. Portland, OR: Bonneville Power Administration and U.S. Army Corps of Engineers.

Johnson GE, HL Diefenderfer, AB Borde, EM Dawley, BD Ebberts, DA Putman, GC Roegner, MT Russell, JR Skalski, RM Thom and JI Vavrinc. 2008. *Evaluating Cumulative Ecosystem Response to Restoration Projects in the Columbia River Estuary, Annual Report 2007*. PNNL-17437. Richland, WA: Pacific Northwest National Laboratory. Prepared for U.S. Army Corps of Engineers, Portland District, Portland, OR.

Johnson GE, KL Fresh and NK Sather, Eds. 2018. *Columbia Estuary Ecosystem Restoration Program: 2018 Synthesis Memorandum*. Richland, WA: Pacific Northwest National Laboratory. PNNL-27617, Final report submitted by Pacific Northwest National Laboratory to U.S. Army Corps of Engineers, Portland District, Portland, OR. Available at <https://www.cbfish.org/FileResource.mvc/DownloadPdfFileResource/ac2b21e9-903a-4428-bbc9-13db44abf025>.

Johnson GE, RM Thom, BD Ebberts, AB Borde, AM Coleman, S Breithaupt, C Corbett, DA Jay, K Leffler, CA Studebaker, HL Diefenderfer, GC Roegner, JR Skalski, EM Dawley, DL Woodruff, A Cameron, EE Donley, Y Ke, C McNeil, J Tagestad and EM Dawley. 2012. *Evaluation of Cumulative Ecosystem Response to Restoration Projects in the Lower Columbia River and Estuary – Final Annual Report*. PNNL-20296. Richland, WA: Pacific Northwest National Laboratory.

Johnson GE, RM Thom, AH Whiting, GB Sutherland, T Berquam, BD Ebberts, NM Ricci, JA Southard and JD Wilcox. 2003. *An Ecosystem-Based Approach to Habitat Restoration Projects with Emphasis on Salmonids in the Columbia River Estuary*. PNNL-14412. Richland, WA: Pacific Northwest National Laboratory.

Krueger KL, DL Bottom, WG Hood, GE Johnson, KK Jones and RM Thom. 2017. "An Expert Panel Process to Evaluate Habitat Restoration Actions in the Columbia River Estuary." *Journal of Environmental Management* 188:337-350. DOI: 10.1016/j.jenvman.2016.11.028.

KTOI. 2005. *Kootenai River White Sturgeon Recovery Implementation Plan and Schedule (2005-2010)*. Bonners Ferry, ID: Kootenai Tribe of Idaho (KTOI). Prepared by S. P. Cramer and Associates for the Kootenai Tribe of Idaho, with assistance from the Kootenai River White Sturgeon Recovery Team.

KTOI. 2009. *Kootenai River Habitat Restoration Project Master Plan: A Conceptual Feasibility Analysis and Design Framework*. Bonners Ferry, ID: Kootenai Tribe of Idaho (KTOI).

Marotz BL, DL Gustafson, C Althen, U Montana State, Montana and S United. 1994. *Hungry Horse Mitigation: Aquatic Modeling of the Selective Withdrawal System-Hungry Horse Dam, Montana*. DOE/BP-60559-1. Portland, OR: Bonneville Power Administration. Available at <http://hdl.handle.net/2027/uc1.31210018652816>.

McNatt R and SA Hinton. 2017. "Evidence for Direct use of Tidal Wetlands by Interior Stocks of Juvenile Salmon." Presented at *Anadromous Fish Evaluation Program, Annual Meeting*, November 28, 2017, Richland, WA.

NMFS. 1995. *BIOLOGICAL OPINION: Reinitiation of Consultation on 1994-1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years*. Washington, D.C.: NOAA Fisheries. March 2, 1995.

NMFS. 2011. *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead*. Portland, OR: NOAA Fisheries. Prepared by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc., subcontractor. Available at <https://repository.library.noaa.gov/view/noaa/17401>.

NMFS. 2012a. *Endangered Species Act - Section 7 Programmatic Consultation Conference and Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation*. Seattle, WA: National Marine Fisheries Service (NMFS). Revised Standard Local Operating Procedures for Endangered Species to Administer Maintenance or Improvement of Stormwater, Transportation, and Utility Actions Authorized or Carried Out by the U.S. Army Corps of Engineers in Oregon (SLOPES for Stormwater, Transportation or Utilities). NMFS Consultation No. NWR-2013-10411.

NMFS. 2012b. *Endangered Species Act Section 7 Formal Programmatic Opinion, Letter of Concurrence and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Conservation Recommendations*. Seattle, WA: National Marine Fisheries Service (NMFS). Revisions to Standard Local Operating Procedures for Endangered Species to Administer Actions Authorized or Carried Out by the U.S. Army Corps of Engineers in Oregon (SLOPES IV In-water Over-water Structures). NMFS Consultation No. 2011/05585.

NMFS. 2012c. *Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation: Snake River Fall Chinook Salmon Hatchery Programs, ESA Section 10(a)(1)(A) Permits, Numbers 16607 and 16615*. Portland, OR: NOAA Fisheries. October 9, 2012. NMFS Consultation No. NWR-2011-3947 and NWR-2011-3948.

NMFS. 2013. *Endangered Species Act - Section 7 Programmatic Consultation Conference and Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response*. Seattle, WA: National Marine Fisheries Service (NMFS). Revisions to Standard Local Operating Procedures for Endangered Species to Administer Stream Restoration and Fish Passage Improvement Activities Authorized or Carried Out by the U.S. Army Corps of Engineers in the Oregon (SLOPES V Restoration). NMFS Consultation No. NWR-2013-9717.

NMFS. 2014a. *Module for the Ocean Environment*. Portland, OR: NOAA Fisheries. Prepared by the Northwest Fisheries Science Center for NOAA Fisheries, Northwest Regional Office. Available at https://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/Final%20Snake%20Recovery%20Plan%20Docs/ocean_module_nov_2017.pdf.

NMFS. 2014b. *Supplemental Recovery Plan Module for Snake River Salmon and Steelhead: Mainstem Columbia River Hydropower Projects*. Portland, OR: NOAA Fisheries, West Coast Region. Available at https://archive.fisheries.noaa.gov/wcr/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/hydro_supplemental_recovery_plan_module_063014.pdf.

NMFS. 2016. *2015 Adult Sockeye Salmon Passage Report*. Portland, OR: NOAA Fisheries in collaboration with the US Army Corps of Engineers and Idaho Department of Fish and Game. Available at https://archive.fisheries.noaa.gov/wcr/publications/hydropower/fcrps/2015_adult_sockeye_salmon_passage_report.pdf.

- NMFS. 2019. *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*. Portland, OR: NOAA Fisheries, West Coast Region. NMFS Consultation No. WCRO-2018-00152. Available at https://www.westcoast.fisheries.noaa.gov/publications/hydropower/fcrps/master_2019_crs_biological_opinion_1.pdf.
- NPCC. 2004. *Okanogan Subbasin Plan*. Prepared for the Northwest Power and Conservation Council (NPCC). Available at https://www.nwcouncil.org/sites/default/files/EntirePlan_screen_3.pdf.
- NPCC. 2015. *Draft Seventh Power Plan*. Portland, OR: Northwest Power and Conservation Council (NPCC). Council Document Number 2015-09. October 20, 2015. Available at <https://www.nwcouncil.org/energy/previous-energy-plans/draft-seventh-power-plan>.
- PNUCC. 2014. *The Northwest & 111(d)*. Portland, OR: Pacific Northwest Utilities Conference Committee (PNUCC). October 10, 2014. Available at <https://pnucc.org/sites/default/files/The%20Northwest%20and%20111d%202014%201009%20final.pdf>.
- Reclamation. 2012. *Finding of No Significant Impact Final Environmental Assessment: John W. Keys III Pump-Generating Plant Modernization Project*. Grand Coulee, WA: U.S. Department of the Interior, Bureau of Reclamation (Reclamation), Pacific Northwest Region, Grand Coulee Power Office. Available at <https://www.usbr.gov/pn/programs/ea/wash/jkpgp/FONSlandEA.pdf>.
- Reclamation. 2018. *Hungry Horse Powerplant Modernization and Overhaul Project: Finding of No Significant Impact, Final Environmental Assessment, Hungry Horse Dam, Hungry Horse, Montana*. Boise, ID: U.S. Department of the Interior, Bureau of Reclamation (Reclamation), Pacific Northwest Region. Available at <https://www.usbr.gov/pn/programs/ea/montana/hungryhorse/fonsiea2018.pdf>.
- Reclamation. 2019. *Finding of No Significant Impact, Final Environmental Assessment: Third Power Plant G19-G21 Modernization Project, Okanogan County, Washington*. Grand Coulee, WA: U.S. Department of the Interior, Bureau of Reclamation (Reclamation), Pacific Northwest Region, Grand Coulee Power Office. Available at <https://www.usbr.gov/pn/programs/ea/wash/tpp/TPPG1921final.pdf>.
- RMJOC. 2018. *Climate and hydrology datasets for RMJOC long-term planning studies: Second edition, (RMJOC-II) Part I: Hydroclimate projections and analyses*. River Management Joint Operating Committee (RMJOC). Produced by the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation. Available at <https://www.bpa.gov/p/Generation/Hydro/hydro/cc/RMJOC-II-Report-Part-I.pdf>.
- Roegner GC, HL Diefenderfer, AB Borde, RM Thom, EM Dawley, AH Whiting, SA Zimmerman and GE Johnson. 2009. *Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary*, Seattle, WA: U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NWFSC-97.
- Sather NK, AB Borde, HL Diefenderfer, JA Serkowski, AM Coleman and GE Johnson. 2013. *The Oncor Geodatabase for the Columbia Estuary Ecosystem Restoration Program: Handbook of Data Reduction Procedures, Workbooks, and Exchange Templates*. PNNL-22922. Richland, WA: Pacific Northwest National Laboratory. Report version December 2013 submitted to the U.S. Army Corps of Engineers, Portland, OR.
- Sather NK, R McNatt, AM Martin-Schwarze, KF Mackereth and GE Johnson. 2017. "Direct Benefits of Habitat Restoration on Juvenile Salmon: Site-Scale Evaluation." Presented at *USACE's Anadromous Fish Evaluation Program Annual Review*, November 28, 2017, Richland, WA. PNNL-SA-130869.

Turecek A, J Tennyson, K Collis and B Cramer. 2018. *Final Annual Report: Double-Crested Cormorant Monitoring on East Sand Island, 2017*. IDIQ Contract No. W912EF-14-0004. Portland, OR: Real Time Research, Inc. Prepared for the U.S. Army Corps of Engineers, Portland District. Available at <https://usace.contentdm.oclc.org/utis/getfile/collection/p16021coll3/id/791>.

USFWS. 2005. *Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary: Final Environmental Impact Statement*. Portland, OR: U.S. Fish and Wildlife Service (USFWS). Available at https://www.fws.gov/pacific/migratorybirds/pdf/Caspian_Tern_Final_EIS.pdf.

USFWS. 2013. *Biological Opinion for the Kootenai River Native Fish Conservation Aquaculture Project*. FWS Reference: OIEIFWOO-2013-FC-0207 (501.2900).

Vermeyen TB. 2006. *Hungry Horse Selective Withdrawal System Evaluation 2000-2003*. Hydraulic Laboratory Report HL-2006-06. Denver, CO: Bureau of Reclamation.

Weitkamp LA, K Jacobson, B Beckman, K Fresh and A Munguia. 2017. "Indirect Benefits of Habitat Restoration on Juvenile Salmon: Landscape-Scale Evaluation." Presented at *Anadromous Fish Evaluation Program, Annual Meeting*, November 28, 2017, Richland, WA.

3 STATUS OF THE SPECIES AND ANALYSES OF ACTION EFFECTS

This chapter provides a description of the status of the ESA-listed species (fish, wildlife, and plants) within the action area (Table 1-1 from Introduction), including life history, habitat (including designated critical habitat), distribution, status, and trends. This chapter also describes the effects of all past and current human and natural factors that have led to the current status of the species. For critical habitat, the discussion includes the extent of designated critical habitat, physical or biological features (PBFs), and any activities that have been identified as having the potential for altering the PBFs.

As the analyses show, the distribution and abundance of these species are influenced by a variety of biotic and abiotic factors they interact with at different life stages. The ESA-listed species described herein utilize a broad range of habitats depending on life stage, and can thus be more (or less) sensitive to natural and/or anthropogenic stressors depending on when and where those stressors overlap with the species' presence.

For context, it should also be noted that there are a host of other actors in addition to the CRS Action Agencies who are formally engaged in mandated and voluntary actions to address a wide range of impacts to fisheries of the Columbia River Basin. From 2010 to 2019 NOAA and FWS have completed several hundred "formal" and "formal programmatic" BiOps applicable to actions that impact ESA-listed fish throughout the basin. Many of these BiOps address impacts that are upstream, downstream and inland from CRS management and non-operational conservation measures, as well as related mitigation activities, including non-CRS Action Agency activities and impacts (see illustrative list below):

- hydroelectric dam operations and assets and related fish passage, turbine mortality, predation, migration timing, water levels, habitat blockage, and, all related incidental take;
- water quality and related impacts of water temperature, total dissolved gas, withdrawals, storage, irrigation, siltation, pollution, farming, grazing, logging, mining, standards compliance and enforcement, dredging, berth deepening, and, all related incidental take;
- habitat, conservation and land management and related impacts of floodplain management, road and bridge projects, other construction near water ways, forestry practices, agricultural practices, marine docking and transportation, and, all related incidental take; and,
- hatcheries and harvest management and related impacts of competition and interbreeding, commercial and recreational fish harvest, decadal or year-to-year changes in ocean rearing environments, drought conditions, hatchery take for propagation, disease and toxics exposure, and, all related incidental take.

The region's collective ability to successfully carry out actions that benefit salmon and steelhead is dependent on the common factors noted below, in combination with the actions included in this Proposed Action. It is also dependent on sustained compliance with regulatory requirements and building upon successful implementation efforts to date by addressing the priority limiting factors that remain across the region.

3.1 NATIONAL MARINE FISHERIES SERVICE SPECIES

This section addresses listed anadromous salmon and steelhead species under the regulatory jurisdiction of the National Marine Fisheries Service (NMFS). After explaining common factors affecting the status of listed salmon and steelhead, the analyses proceed according to region: Snake River; upper, middle, and lower Columbia River; and Willamette River. The section closes with a discussion of a non-salmonid, Eulachon, also under NMFS's jurisdiction.

3.1.1 Common Factors Affecting the Status of Listed Salmon and Steelhead

This section describes the influence of large-scale biotic and abiotic stressors to anadromous salmon and steelhead that are, for the most part, experienced by all the ESUs and DPSs addressed in this BA. These environmental factors can dramatically influence the reproduction, numbers, and distribution of salmon and steelhead, as well as the function of these species' habitat. After describing general facts of salmon and steelhead survival by life stage, this section focuses on the five most significant factors affecting the status of all salmon and steelhead ESUs and DPSs—tributary habitat carrying capacity and density dependence, juvenile outmigrant survival, predation in the Columbia River Basin, ocean conditions, and climate change.¹

3.1.1.1 *Relative Survival of Salmon and Steelhead by Life Stage*

Environmental conditions, such as water quantity, quality, depth, and velocity; cover; substrate; vegetation; and prey availability, are important parameters that define habitat for a diverse array of aquatic plants and animals, including the ESA-listed species described in this BA. Many of these conditions, however, are subject to a range of external stressors that are primarily driven by conditions outside the control of CRS operations. This is particularly true for anadromous species that spend the majority of their lives in the ocean and in tributaries, far removed from the influence of CRS management. In particular, time spent exposed to effects of CRS management is less than time spent in spawning and rearing tributaries in watershed areas above and in marine environments that are beyond the effects of CRS operations (Figure 3-1.).

¹ The estuary, defined as the 234-km tidally influenced portion of the Columbia River from Bonneville Dam to the ocean, could also be viewed as a basin-wide factor because all anadromous salmonid populations use it during their downstream and upstream migrations. Estuary conditions, however, are covered in the individual species sections.

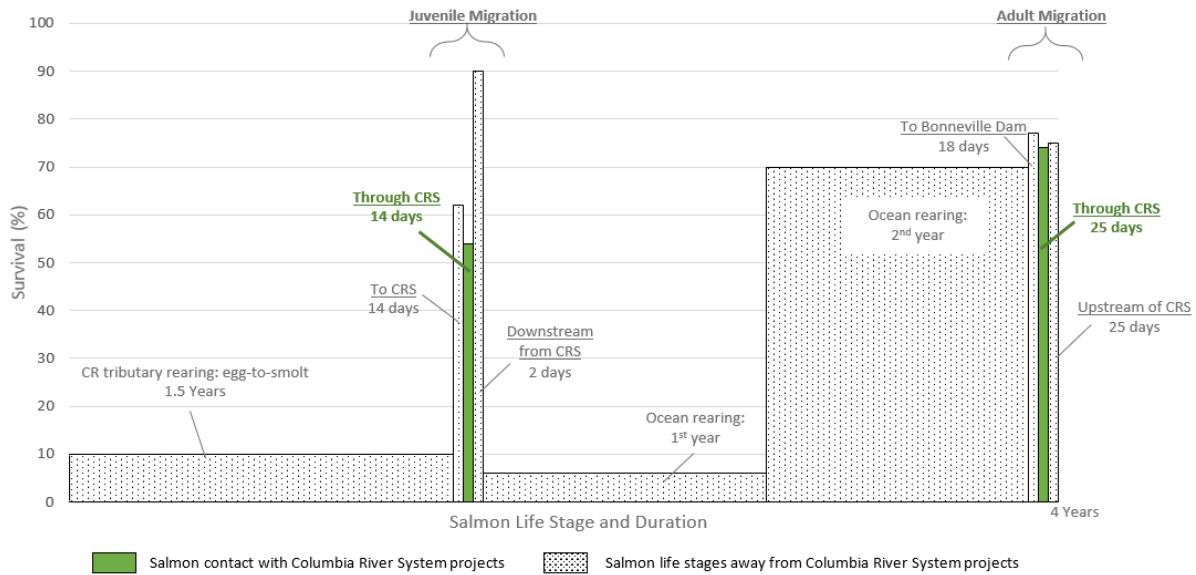


Figure 3-1. SR spring/summer Chinook salmon example survivals by life stage

To illustrate this dynamic and place the effects of CRS management in the context of an anadromous salmonid’s complete life cycle, this section provides an example of survival by life stage for one specific ESU—Snake River (SR) spring/summer Chinook salmon. Many factors, both natural and anthropogenic, affect the survival rates reported here. It is safe to say, however, that each life stage is affected by multiple environmental conditions, many of which are not the result of CRS operations.

The SR spring/summer Chinook salmon ESU has two particularly vulnerable life stages (Healey 1991; Federal Caucus 2000; NMFS 2014b, 2019). During the first egg-to-smolt life stage, salmon and steelhead exhibit a K-selection evolutionary strategy, where a female will produce thousands of eggs and survival rates are often below 18% (Keefer et al. 2007). Put differently, it is not unusual for more than 80% of this species to perish before exposure to CRS operations. The second particularly vulnerable life stage is the first year in the ocean, explaining in part why ocean indicators can be used to predict adult salmon returns to the Columbia River (Peterson et al.).

Figure 3-1 illustrates SR spring/summer Chinook ESU survival rates by life stage. These survival rates are relatively similar for other ESUs and DPSs. Listed salmon and steelhead species spend most of their life cycle in the ocean and the tributaries; only a small fraction of their life cycle is exposed directly to CRS operations. The figure splits the juvenile migration period into three sections: the time it takes for SR spring/summer Chinook to migrate from their natal tributaries to the CRS mainstem (i.e., Lower Granite Dam); time migrating through the CRS mainstem dams; and time migrating through the mainstem downstream of Bonneville Dam, all before they enter the ocean. The figure also shows that juvenile survival during migration through the CRS (the first green column in Figure 3-1) is comparable to juvenile survival migrating over a similar migration distance upstream of the CRS dams where no dams are present (the adjacent “to CRS” stippled column).

The y-axis shows approximate survival percentage by life stage. Again, these values are specific to SR spring-run Chinook and are not directly applicable to all other salmon and steelhead species, but are

useful as a relative comparison to show general trends. The x-axis and widths of the vertical bars represent the approximate duration of each life stage (not to scale). Life stages shown here include juveniles rearing in Columbia River tributaries (egg-to-smolt), juvenile migration to the most upstream CRS dam, juvenile migration through the CRS, juvenile migration below the CRS to the ocean, first-year ocean rearing, second-year ocean rearing, adult migration from the ocean to the most downstream CRS dam, adult migration through the CRS, and adult migration upstream of Lower Granite Dam. The Action Agencies assumed a four-year life cycle for this example. Juvenile and adult migration to and from the CRS may also be directly and indirectly impacted by CRS operations due to potential latent mortality and reservoir effects (see Appendix F).

3.1.1.2 Tributary Habitat Carrying Capacity and Density Dependence

The history and sequence of landscape changes associated with development in the Columbia River Basin explain the current physical conditions of streams and watersheds and, thus, their ability to support salmonid populations (Figure 3-2). It has been estimated that roughly one-third of the Columbia River Basin is no longer accessible to anadromous salmon (ISAB 2015). Continuing changes to environmental conditions from climate change, chemicals, and intensified land use appear to have further diminished the capacity of habitat that remains accessible (ISAB 2015).

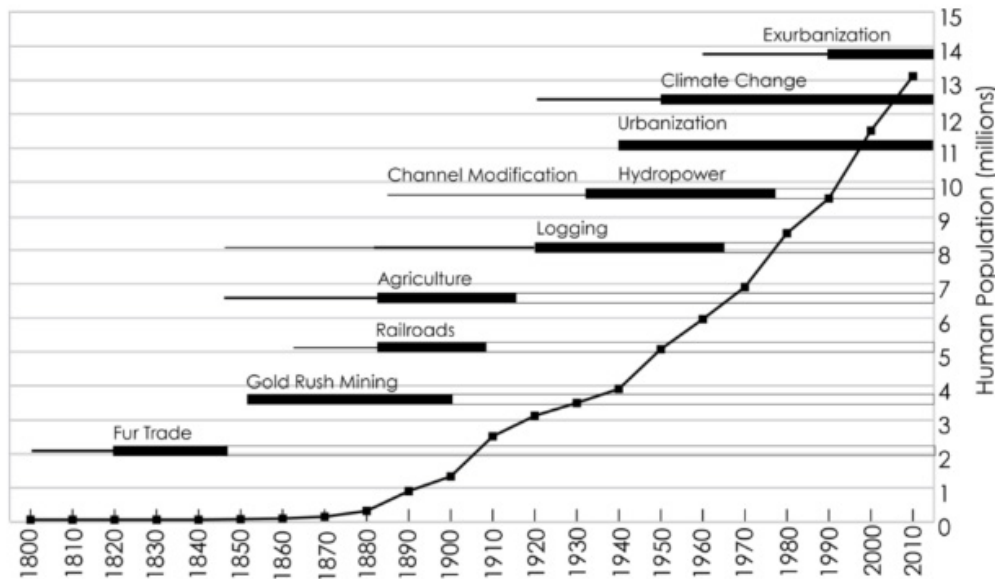


Figure 3-2. Sequential development driving landscape change in the U.S. portion of the Columbia River Basin and concurrent changes in human population size. Wide dark bars indicate the period of peak development and rapid conversion. Wide light bars indicate continued effects following the initial period of rapid change [from ISAB (2011)].

The Independent Scientific Advisory Board (ISAB) concluded that there is density dependence within many fish populations, notably Chinook salmon and steelhead, within the Columbia River Basin (Zabel et al. 2006; Walters et al. 2013; Zabel and Cooney 2014; ISAB 2015). Density dependence occurs when a population’s density affects its growth rate by changing one or more vital rates such as birth, death,

immigration, or emigration. Population density can also be discussed in terms of carrying capacity, or the maximum number of individuals in a population that the resources of a habitat can support (Ricklefs 1990; Cain et al. 2014). A population density that is near to or exceeds carrying capacity can diminish growth in individuals, induce behaviors to reduce competition, and ultimately affect the survival of individuals within a population. Density-dependent factors, like competition for available resources and disease, become more influential as populations reach and sometimes exceed a habitat's carrying capacity. Thus, even small populations can exceed carrying capacity when habitat is degraded and unable to support large numbers of individual organisms.

Evidence of density dependence in mainstem and tributary habitats has been examined for populations from upper Columbia River (UCR) spring-run and SR spring/summer-run Chinook salmon ESUs (Zabel and Cooney). Of the 27 populations studied, 25 exhibited strong density dependence, revealed by a decline in productivity as spawner abundance increased. Productivity is the number of offspring or recruits (R) produced by the parent generation per number of spawners. ISAB (2015) found reduced productivity (R/S) as spawner abundance increased; there was a similar decline in productivity of 20 interior Columbia River (CR) steelhead populations from the upper Columbia River, Snake River, and middle Columbia River (MCR) DPSs. Density dependence was also observed in SR fall-run Chinook [Cooney (2014) as cited in Connor et al. (2013); ISAB (2015)]. The life cycle recruitment relationships presented by ISAB (2015) exhibited strong density dependence. Note: if R/S goes down, it is the juvenile life stage that is affected.

The widespread occurrence of density dependence noted by ISAB (2015) indicated that density-independent factors alone, like stream temperature or streamflow, could not explain the decline in productivity. The significance of those findings and others presented by ISAB (2015) is that the current carrying capacity for anadromous salmon in tributary spawning and rearing areas has been exceeded in recent years, implying that carrying capacity in these tributaries has been reduced given that salmon populations are diminished. In fact, studies reviewed by ISAB indicate that freshwater habitat capacity is limiting growth and survival even though current spawning abundances are low relative to historical levels (ISAB 2015). Hence, freshwater habitat conditions in spawning and rearing areas may be limiting species survival and recovery by reducing abundance and productivity of some populations.

It is difficult to detect density dependence during spawning and incubation because density-independent effects such as sedimentation, freezing, stream scour, temperature, and streamflow can be responsible for significant mortality. However, in controlled experiments with chum salmon and Chinook salmon, conversion of eggs to fry decreased as the density (females/m²) of female spawners increased. Chinook salmon were less tolerant to increases in spawner density than chum salmon (ISAB 2015). This may suggest that chum, pink, and sockeye salmon, which often spawn in dense aggregations, are adapted to higher spawner densities than perhaps Chinook, coho, and steelhead that typically spawn at lower relative densities. Indicators of density dependence during spawning/incubation may present as increased redd superimposition, increased spawner aggression, decreased egg-to-fry survival, decreased redd size, and increased egg retention (ISAB 2015). ISAB (2015) noted that evidence of crowding on spawning grounds was observed in SR fall-run Chinook salmon during recent years of high spawning escapement. SR fall-run Chinook salmon was one of the populations indicated as exhibiting density dependence by ISAB (2015).

For juveniles, density-dependent factors can influence growth, dispersal, and survival (Achord et al. 2003; Achord et al. 2007; Copeland and Venditti 2009; Connor et al. 2013; Walters et al. 2013; Copeland et al. 2014). For instance, Connor et al. (2013) showed that juvenile SR fall-run Chinook salmon responded to higher juvenile abundance by emigrating sooner (17 days) from natal habitats and that early migrants were on average smaller by 10 mm and 1.8 g than later migrants. In the Pahsimeroi River, Copeland and Venditti (2009) found that juvenile Chinook salmon length at emigration and survival was influenced by initial cohort abundance. As initial juvenile abundance increased, a greater proportion of juveniles adopted the age-1 smolt and fall parr migrant life history. However, the fall parr migrant had the lowest median survival probability (0.27) to Lower Granite Dam compared to age-1 (0.56) and age-0 (0.51) migrant life histories. Zabel and Achord (2004) found that survival of juvenile Chinook salmon cohorts was positively related to mean body length, which is often related to fish density. Zabel et al. (2006) indicated that density-dependent recruitment for juvenile spring/summer Chinook salmon was found to be one of the top two variables explaining population viability. This indicates that increases in freshwater carrying capacity are needed to increase juvenile abundance, which the authors noted will be important to recovery. Their results indicate that density dependence that occurs during freshwater life stages can be a more important factor affecting population status than many ocean, climate, or hydrosystem-related parameters (Zabel et al. 2006).

Evidence of density-dependent growth and survival was found in nine populations of SR spring/summer run Chinook salmon, but there was no evidence that density dependence made them move to other locations (Walters et al. 2013). In that study, overwinter mortality, spatial clustering of redds, and limited resource availability were identified as potentially important limiting factors contributing to density dependence. Degraded habitat conditions (Paulsen and Fisher 2001), presence of exotic competitors (Levin et al. 2002), and hatchery supplementation (Kostow et al. 2003; Kostow and Zhou 2006; Hanson et al. 2010) have also been shown to influence density-dependent responses.

Targeting appropriate life-stage-specific habitat restoration actions could increase habitat capacity, support survival, and contribute to recovery by increasing population productivity and abundance (see (Roni et al. 2014; Hillman et al. 2016). Barrier removal projects and recolonization studies have shown population-level responses to reopening large amounts of habitat (Roni et al. 2008; Pess et al. 2012). In addition, targeted restoration actions have been shown to increase and help sustain pool habitat, and large woody debris can increase habitat capacity and complexity (Tippary et al. 2010; Jones et al. 2014). Positive biological responses in the form of increased survival and abundance with similar habitat restoration actions have been observed (Johnson et al. 2005; White et al. 2011; Pierce et al. 2013). Increases in juvenile Chinook abundance associated with pool habitat in one study were related to an increase in habitat capacity and not simply a redistribution of fish (Polivka et al. 2015). Collectively, these studies and others indicate that restoring habitat capacity can contribute to increased productivity, survival, abundance, and distribution of native salmonids (Roni et al. 2014; Hillman et al. 2016).

Hinrichsen and Paulsen (2019) have indicated that density dependence in SR spring-summer Chinook salmon occurs at both the spawner-to-parr and parr-to-adult life history segments. Their results illustrate the importance of recognizing density dependence because, as noted, simply delivering more smolts to the ocean may not substantially increase the number of adult returns to the spawning grounds. Although the scientific discussion of density dependence has focused on freshwater spawning

and rearing areas, ISAB (2015) noted a growing body of literature that suggests marine environments are subject to changes in productivity due to changes in ocean conditions. Ocean conditions fluctuate and may be influenced by important biophysical alterations such as climate change, acidification, pollution, and a relatively constant and large number of hatchery fish regardless of ocean conditions. The effects of these strategies in reducing the direct passage mortality are relatively well established and undisputed. However, their effects on reducing delayed mortality in the estuary and ocean are not well established. In particular, differing analyses have reached conflicting conclusions and consequently, the effect of the strategies on adult returns has not been resolved.

3.1.1.3 Juvenile Outmigrant Survival

This section focuses on factors affecting survival of listed anadromous fish during their downstream migration. While some factors are clear and direct, others are subtle, indirect, and cumulative. Factors affecting outmigrant survival can occur upstream, within, or downstream of the CRS, and involve baseline, cumulative, and CRS operation effects. They are discussed here rather than being repeated for each ESU or DPS within this BA. Components of CRS operations designed to improve outmigrant survival include flow augmentation, spill, transportation, predator management, and surface-oriented passage systems.

The discussion starts with current and historic estimates of survival in the CRS to provide context. For additional perspective, these survival rates are compared to outmigrant survival through free-flowing tributaries. The section then covers role of migration distance, factors influencing outmigrant survival, and predation, before closing with a brief discussion of hypothesized latent/delayed mortality.

IN-RIVER SURVIVAL ESTIMATES

Annual in-river survival through the CRS has improved with the structural and operational changes to the CRS over the last decade (NMFS 2017a). These changes include surface passage routes at all eight run-of-river dams on the lower Snake and lower Columbia rivers. The surface-oriented passage routes include spillway surface weirs at six dams; a corner collector sluiceway at Bonneville Dam Second Powerhouse; and ice and trash sluiceways at Bonneville Dam First Powerhouse and The Dalles Dam.

To illustrate the improvement in passage survival, estimates of downstream passage survival for Snake River spring/summer Chinook salmon, sockeye salmon, and steelhead are summarized below. Figure 3-3 shows in-river survival for the most recent years (2007–2018) for juvenile SR Chinook salmon, sockeye salmon and steelhead. These estimates were compared to a base period (1980–2001), which was before completion of most of the operational and structural improvements were completed. For wild SR steelhead smolts from Lower Granite to Bonneville Dam, the average in-river survival improved from 27 percent in the base period to 47 percent in the 2007-2018 period (NMFS 2017a; Widener et al. 2019). Average survival for wild yearling SR spring/summer Chinook salmon has likewise improved from 33.4% during the base period to 51.0%. The 11-year in-river survival rates for wild and hatchery-origin (combined) SR sockeye salmon smolts is 44.5%. However, no survival estimates for sockeye are available during the 1980–2001 base period to estimate a percent improvement. Note the low sockeye survivals in 2016 and 2017 were the result of hatchery operations (Kline et al. 2019).

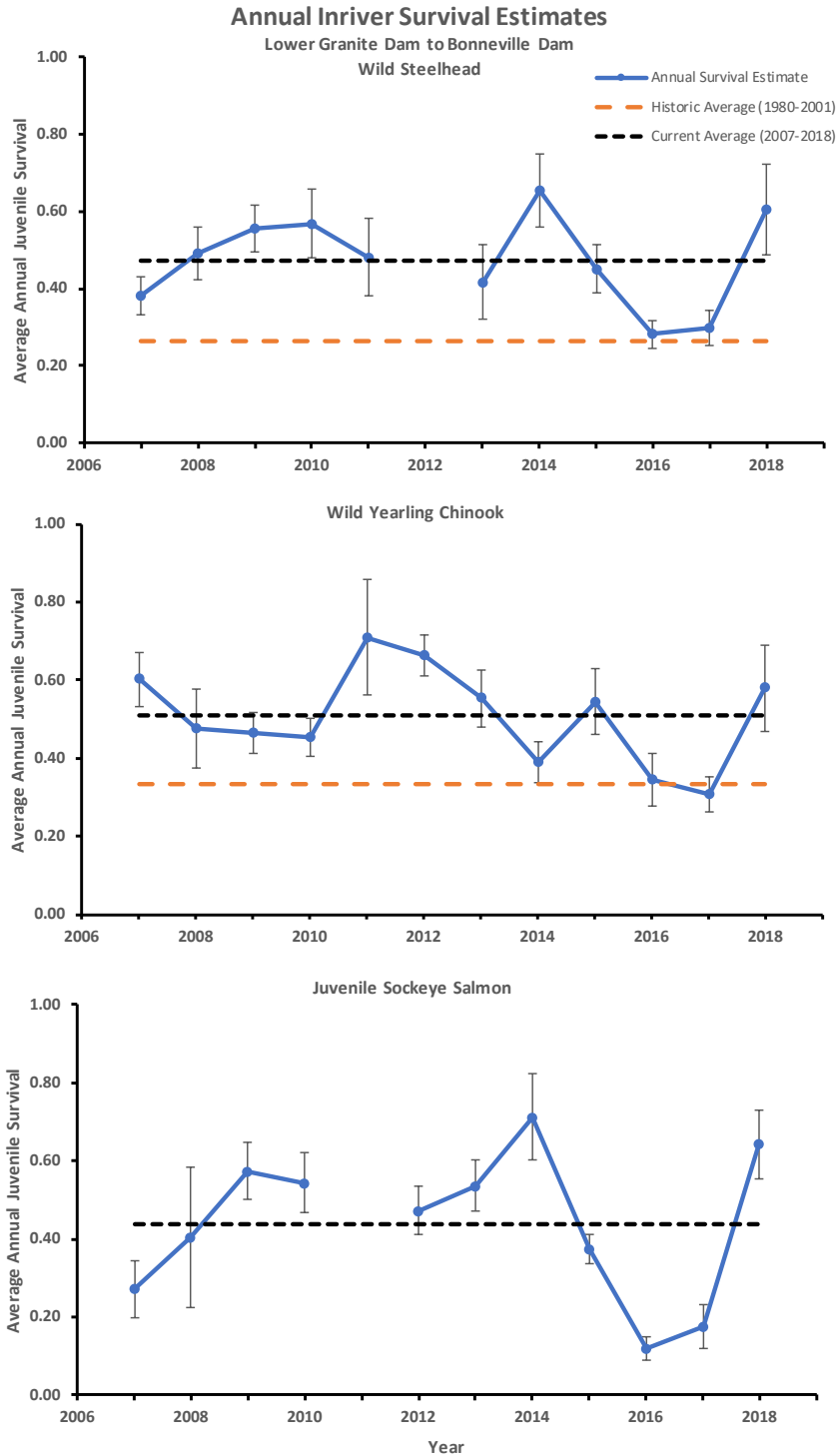


Figure 3-3. Annual in-river survival estimates and standard error bars for wild steelhead and yearling Chinook and sockeye salmon from Lower Granite Dam to Bonneville Dam (LGR→BON), 2007–2018 (Widener et al. 2019). Historical (1980–2001) and current (2007–2018) average in-river survival rates through the CRS reach (LGR→BON) are plotted (dashed lines) for comparison.

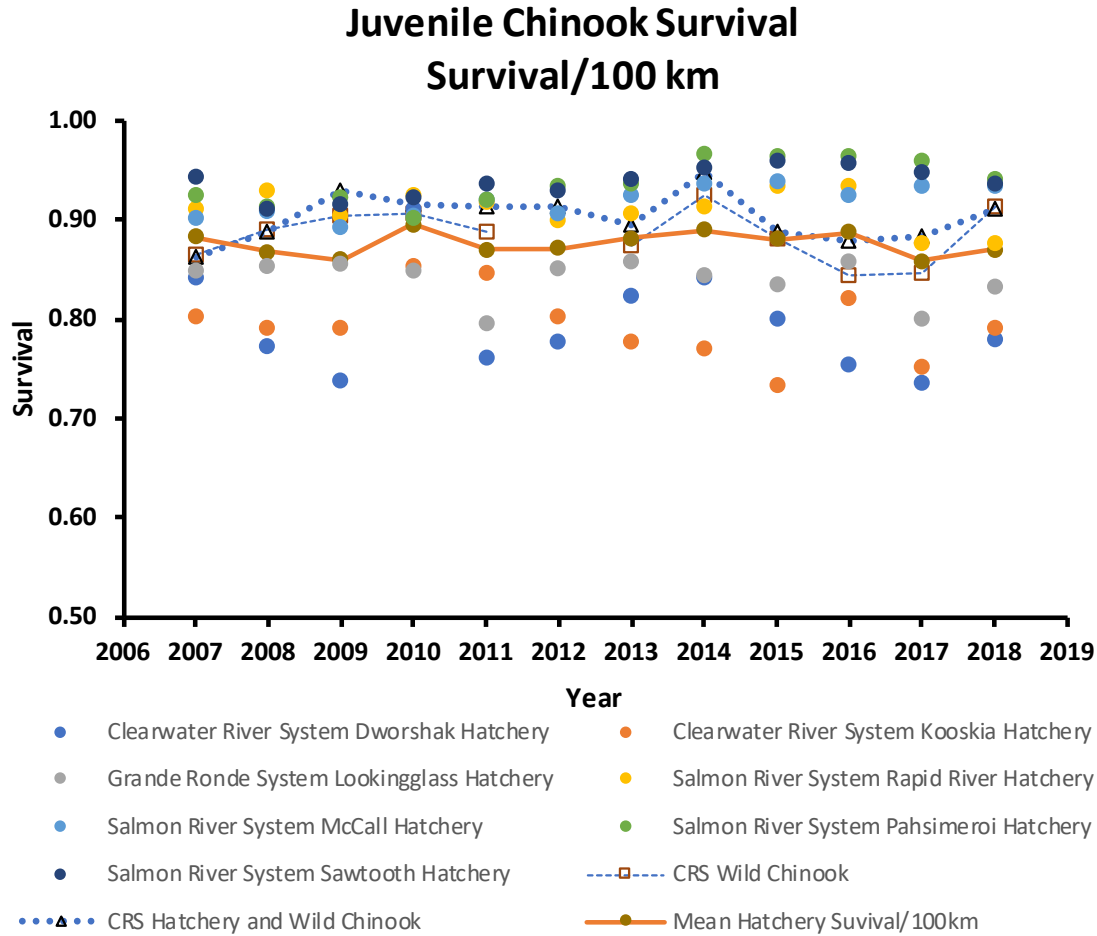


Figure 3-4. In-river survival estimated per 100 km of migration distance for juvenile hatchery Chinook released in the Clearwater River, Grande Ronde River, and Salmon River systems compared to juvenile Chinook survival within the CRS. Survival was estimated for hatchery Chinook within the reach from tributary release locations to the tailrace of Lower Granite Dam. Survival estimates per 100 km of migration distance for wild juvenile Chinook and combined wild and hatchery juvenile Chinook from Lower Granite Dam to Bonneville Dam (data from Widener et al. 2019). Connected symbols represent survival of juvenile Chinook through the CRS. Stand-alone symbols represent survival through free-flowing reaches of rivers (i.e., Grande Ronde River, Clearwater River, and Salmon River) upstream from Lower Granite Dam.

MIGRATION DISTANCE

Downstream migration survival is a function of migration distance (Widener et al. 2018), passage routes experienced (Čada 2001; Skalski et al. 2002; Zabel et al. 2008), and migration conditions and number of dams passed (Elder et al. 2016). Based on SR hatchery yearling Chinook salmon released upstream of the CRS, Widener et al. (2019) demonstrated an inverse relationship between survival and migration distance from hatchery release sites to Lower Granite Dam (Figure 3-5).

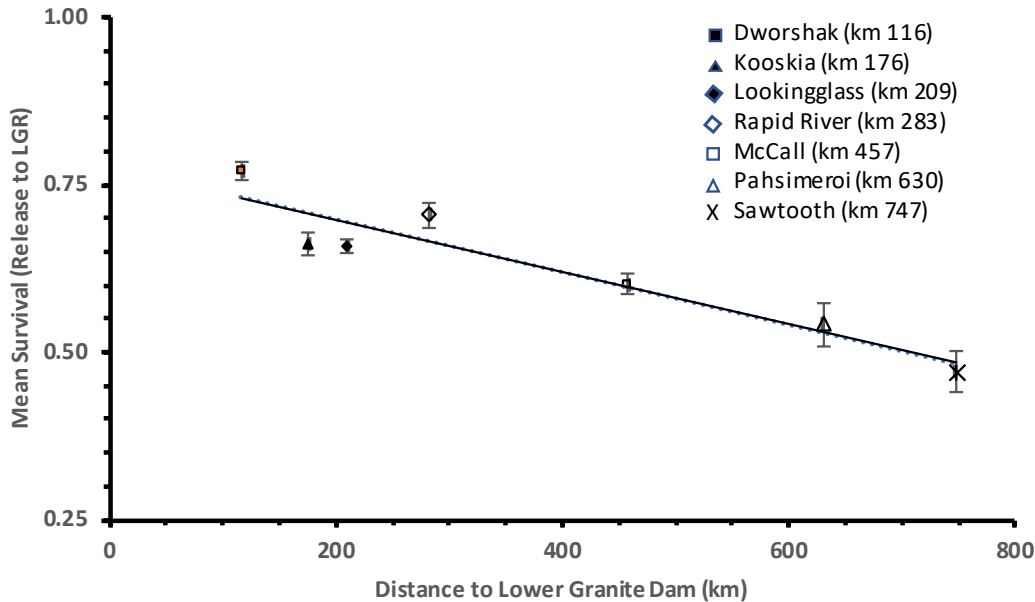


Figure 3-5. Mean estimated survival for hatchery yearling juvenile Chinook salmon from release at Snake River Basin hatcheries to Lower Granite Dam tailrace, 1998–2018 vs. distance (km) to Lower Granite Dam. The coefficient of determination between survival and migration was $R^2 = 0.789$ with a P -value ($p = 0.008$) for a test of the null hypothesis of zero correlation (Widener et al. 2018). Standard errors are presented as whiskers for each mean survival estimate.

FACTORS INFLUENCING OUTMIGRANT SURVIVAL

Stream temperature, discharge, turbidity, and total dissolved gas (TDG) can influence the survival of migrating juvenile salmon (Weitkamp and Katz 1980; Gregory and Levings 1998; Abernethy et al. 2001; Smith et al. 2003; McGrath et al. 2006; Brosnan et al. 2016; Elder et al. 2016). These factors can arise as a result of both baseline conditions and CRS operations. For example, exposure to suboptimal temperature conditions can significantly affect the distribution, health, and survival of native salmonids (EPA 2003). Suboptimal temperatures, however, generally result from causes other than CRS operations, including ambient air temperature, incoming water temperatures, runoff quantity, and reservoir pooling that occurs as a result of the existence of dams. CRS operations can sometimes mitigate harmful baseline temperature conditions; for example, cold water releases from Dworshak Dam occur from about early July through mid-September and can help to increase flow and reduce high temperatures of water entering the CRS. Connor et al. (2003) accordingly found this part of CRS operations to have a positive effect: survival of subyearling fall Chinook salmon in the lower Snake River increased as flow increased and stream temperatures decreased due to temperature-controlled flow augmentation from Dworshak Dam. Please refer to the CRSO EIS, section 3.3.2.1 (sediment supply) for a comprehensive discussion on how the existence of dams trap sediment, which is related to the effects of decreased turbidity, and 3.4.2.1 (water quality) for a discussion of multiple facets related to water temperature, including operational effects (discussion of selective withdrawal operations, stratification from storage operations, etc.), minimal effects observed from run-of-river projects, and historical baseline temperature exceedances in the lower Snake River.

Juvenile salmon vulnerability to predation depends on many environmental factors including stream temperature, discharge, turbidity, and total dissolved gases (TDG) (Weitkamp and Katz 1980; Gregory and Levings 1998; Abernethy et al. 2001; Smith et al. 2003; McGrath et al. 2006; Brosnan et al. 2016; Elder et al. 2016). Exposure to suboptimal temperatures can significantly affect the distribution, health, and survival of salmonids (EPA 2003). In particular, juvenile summer migrants such as subyearling fall Chinook are likely the most vulnerable to elevated stream temperatures (Crozier et al. 2019)). For example, subyearling fall Chinook survival increased with flow augmentation at Dworshak Dam that resulted in increased flow and decreased temperature (Connor et al. 2003). However, cold water releases that occur July through September at Dworshak Dam only affect reservoir water temperatures upstream of Little Goose and Lower Granite dams.

Decreasing fish travel time through reservoirs has been proposed as a way to reduce migration mortality. Three operations have been used in the last two decades to meet this objective through operational and structural changes, which include: lowering Snake River and John Day reservoirs to within 1.5–2 feet of minimum pool during spring and summer, implementation of surface spill (e.g., spillway weirs or modified ice and trash sluiceways at all eight dams) and increasing spillway flows by spilling higher proportions of water. However, reducing fish CRS travel time likely has a minimum effect on direct mortality because PIT tag-based data indicates that CRS survival of Chinook and steelhead are mostly responsive to flow and water temperature. Yearling Chinook salmon in-river survival was moderately sensitive to flow in the Snake River, but insensitive to flow in the Columbia River. Steelhead in-river survival was moderately sensitive to flow in both the Snake and Columbia rivers. For both species, spill only had a noticeable impact on in-river survival at the lowest levels of spill (Appendix 8 page 2, Review DRAFT manual, July 2019 Comprehensive Passage (COMPASS) Model - version 2.0).

Migration distance is also a factor that influences juvenile downstream migration survival. The COMPASS model, field studies (Figure 1 in Widener et al. (2019)) and theory Anderson et al. (2005) indicate passage survival mostly depends on passage distance above and within the CRS. This relationship has been explained as a gauntlet effect in which the survival depends on the number of predators encountered per km not the travel time through the distance (Anderson et al. 2005). Consequently, fish travel time is not expected to have a significant effect on survival in the CRS.

During dam passage, the route of passage experience also affects the direct mortality in the CRS (Čada 2001; Skalski et al. 2002; Zabel et al. 2008). In particular, higher percentages of juveniles passing through spill gates relative to powerhouse turbines results in higher passage survival because direct fish passage survival through non-turbine routes is typically higher than through turbines (Evans et al. 2010; Ploskey et al. 2012; Hughes et al. 2013; Skalski et al. 2014). The metric characterizing the partition of passage between the dams and spillway is denoted Fish Passage Efficiency (FPE). Depending on the location, time of year and species, approximately 70 to 97 percent of juvenile fish use non-turbine passage routes at mainstem Columbia and Snake River dams (Table E-2 in Appendix E). Emerging science is illustrating that fish size is an important biological predictor in where fish passage at most dams (e.g., smaller fish tend to approach dams at deeper depths, interact with powerhouse and pass through bypass systems) (Faulkner et al. 2019).

While spillway passage generally results in higher dam passage survival, the studies were conducted under moderate spill levels which produce moderate levels of total dissolved gas (TDG); generally, less than 120% saturation. In contrast, higher spills at multiple dams can increase the downstream load of

TDG to levels that have not previously been studied which can potentially result in greater ecosystem stress (Ma et al. 2018). Of particular concern is the threshold-like stress response with increasing TDG. At levels of 120% little ecosystem effect is observed but above this level, fish and other aquatic biota exhibit significant signs of gas bubble disease and mortality (Jensen et al. 1986; Ryan et al. 2000; Geist et al. 2013).

PREDATION

Direct mortality of juvenile salmon through the CRS ultimately involves piscivorous fishes and avian predators (Rieman et al. 1991; Beamesderfer et al. 1996; Evans et al. 2012; Evans et al. 2016; Erhardt et al. 2018; ISAB 2019). However, the susceptibility to these predators also depends on the fish's experience in passage through the dams, reservoirs, and transportation system. Predation as a basin-wide factor is discussed in a separate section below covering both adult and juvenile life stages. Here, the emphasis is on general patterns of vulnerability for predation on juvenile migrants.

The primary piscivorous fish predators that prey on juvenile salmon include northern pikeminnow, smallmouth bass, channel catfish, and walleye. ISAB (2019) found that juvenile salmonids were the prey fish most frequently eaten by northern pikeminnow (about 34%). Only 20% of walleye and channel catfish and about 4% of the smallmouth bass had eaten salmonids. Based on higher consumption rates, wide distribution, and greater abundance, researchers considered northern pikeminnow the primary predator of young salmon (Beamesderfer and Rieman 1991; Poe et al. 1991; Vigg et al. 1991). Beamesderfer et al. (1996) estimated that about 16.4 million juvenile salmon, or about 8% of the population, were consumed by northern pikeminnow annually.

The primary species of birds that prey on juvenile salmonids include Caspian terns, double-crested cormorants, American white pelicans, California gulls, ring-billed gulls, and Glaucous-winged gulls (ISAB 2019). Based on PIT tag recoveries, it was estimated that those species collectively consumed over 1 million juvenile salmonids annually between the years of 2004 and 2009 (Corps 2014b). ISAB (2019) categorized juvenile steelhead as the most vulnerable to avian predators and subyearling Chinook salmon as the least vulnerable. As cited by ISAB (2019), preliminary findings reported by Evans et al. (2018) show that avian predation accounted for 47% to 69% of UCR steelhead smolt mortality during emigration from Rock Island Dam to Bonneville Dam. In nine of the ten years evaluated (2008–2017), avian predation exceeded all other sources of UCR steelhead mortality.

ISAB (2019) assigned categorical values of low, medium, and high vulnerability to juvenile salmon with specific avian and piscivorous predators. Vulnerability to predation is thought to be related to body size (Zabel and Achord 2004; Hostetter et al. 2015). For steelhead, larger body size and surface-oriented migration may increase their susceptibility to avian predation (Evans et al. 2016). In contrast, for subyearling Chinook their smaller body size, summer migration period, and habitat use contribute to their greater vulnerability to piscivorous predators (ISAB 2019). Predator control programs have been established to help reduce the effects of predation on juvenile salmon at or near dams and at colonial waterbird nesting sites with high predation rates on juvenile salmon and steelhead (ISAB 2019). These size-selective passage and predation effects complicate the interpretation of the effects on smolt size on survival.

LATENT MORTALITY

The concept of latent mortality relates to any delayed mortality that occurs after salmon and steelhead pass the hydropower system (i.e., after Bonneville Dam) as juveniles, that would not occur if the CRS did not exist. ISAB (2007b) defined latent mortality as the delayed mortality from the downstream passage experience and therefore, latent mortality could be attributed to passage through the different dam routes (spillway, bypass or turbine routes), juvenile transportation, altered environmental conditions, ecological changes in the system, and physiological changes in the fish because the hydropower system exists. However, since no controlled experiments with and without the hydrosystem in existence is possible, latent mortality cannot be quantified in absolute terms. Only relative comparisons between “target” and “reference” groups are possible. For example, smolt-to-adult survival of fish passing through powerhouse routes can be compared to those of fish passing through spillway routes. Similarly, the survival of transported juveniles can be compared to those of run-of-river fish. Quantifying and identifying factors of delayed mortality therefore remain difficult. For this reason and for additional data collection, the region has adopted a “spread-the-risk” policy that partitions migrating fish into spill, transport, and bypass/turbine passage routes (ISAB 2008). Multiple lines of evidence will be important in testing and bolstering competing hypotheses of delayed mortality. Identifying processes of delayed effects helps to determine ways of increasing total smolt-to-adult survival and numbers of adults.

Route-specific differences in delayed effects on smolt-to-adult survival may occur, even though direct survival through spillway, turbine and juvenile bypass routes yield high direct survival of greater than 96 percent (Skalski et al. 2016). Of these three major dam passage routes, the spillway is thought to be most benign route of passage because survival is generally higher at that spillway when compare to turbines, although typically similar to survival of bypassed fish (Muir et al. 2001; Skalski et al. 2014). A number of studies have determined that indices of percent water spilled, water velocity, and number of powerhouses experienced (e.g., PITPH index based on spill and flow covariates) are among the most important covariates of delayed mortality (Petrosky and Schaller 2010; Haeseker et al. 2012; Schaller et al. 2013). However, one major uncertainty is whether selectivity of “weaker” fish is occurring through the bypass route (Zabel and Achord 2004) or if passage through this route causes negative effects to the fish and their survival to adulthood (Budy et al.). Recently, Faulkner et al. (2019) concluded that:

- (1) larger fish had lower bypass probabilities at six of seven dams;*
- (2) larger fish had a higher probability of surviving to adulthood;*
- (3) bypass history had little association with adult return after accounting for fish length; and*
- (4) simulations indicated that spurious effects of bypass on survival may arise when no true bypass effect exists, especially in models without length.*

Our results suggest that after fish leave the hydropower system, bypass passage history has little effect on mortality. Our findings underscore the importance of accounting for fish size in studies of dam passage or survival.

Deciphering between the “selectivity hypothesis” vs. “damage hypothesis” is often not possible given the data we have in hand (Buchanan et al. 2011; Haeseker et al. 2012; Schaller et al. 2013). PIT tag analyses conducted by two separate research groups, Smith et al. (2013) and Buchanan et al. (2011),

hypothesized delayed effects associated with smolt passage through screened bypass systems (ISAB 2012). Poor condition from freshwater experience that result in injuries, fin damage and external signs of disease can also decrease smolt-to-adult survival (Evans et al. 2014). In contrast, fish held for a short-term after their passage experience through a juvenile bypass system expressed no immediate or direct effects (Sandford et al. 2012). Recent, emerging research by Faulkner et al. (2019) suggests that once juvenile fish length is accounted for, hydropower bypass passage history has little effect on marine survival. The research indicated that larger juveniles had lower bypass probabilities at six of seven dams, and larger juveniles had higher probability of surviving to adulthood (i.e., bigger fish are less susceptible to predation and ocean starvation in first winter). Given the overall weight of evidence reviewed by (ISAB 2012) and recent studies, fish bypass systems appear to be associated with delayed mortality to some degree, but the magnitude and factors involved still remain uncertain and potentially limited. Ensuring that analytical approaches and interpretation of results do not *a priori* assume only the selectivity hypothesis or only the damage hypothesis is important.

One major mitigation strategy to help increase survival is the *Juvenile Fish Transportation Program* operated by the U.S. Army Corps of Engineers (Corps 2015c, 2016). The program involves collecting and transporting salmon and steelhead from three Snake River dams to below Bonneville Dam. Juvenile fish transportation was first tested in 1968, fully implemented in 1977, and presently yields nearly 100% survival during barge transportation (McMichael et al. 2011). To gauge the effectiveness of the program, this nearly perfect in-river survival needs to be weighed against any delayed mortality that may occur in the estuary, ocean, and upstream-migrating stages.

Ratios of transported to run-of-river smolt-to-adult survival can be used as indices to gauge the effectiveness of the mitigation strategy (Smith et al. 2013; Corps 2015c). The indices can include hydrosystem survival (e.g., Transport-Bypass [T:B] ratio, Transport-In-River [TIR] ratio, and Transport-Never Detected [T:C0] ratio; Corps (2015c)) or only represent post-hydrosystem survival [e.g., differential delayed mortality [*D*], (Anderson et al. 2005; Anderson et al. 2012)]. Most importantly, these indices can vary through the season and across years (Smith et al. 2013; Corps 2015c; Gosselin et al. 2018a; Gosselin et al. 2018b). For example, in some years transportation is only beneficial late in the season; in other years, transportation is beneficial, neutral or disadvantageous to survival through the whole season.

Drawing from general trends (Anderson et al. 2012; Smith et al. 2013; Corps 2015c; Gosselin et al. 2018a), hatchery salmon and steelhead have values of T:B (or other similar ratio indices) that are equal to or greater than 1, thus indicating neutral and beneficial effects of juvenile transportation on survival. A threshold of 0.5 is used for *D* because 100% survival is assumed during juvenile transportation and 50% survival is assumed for run-of-river fish passing through the hydropower system (Anderson et al. 2012). Hatchery fishes tend to have higher T:B and *D* values than their wild counterparts. Steelhead also tend to show higher values of these indices than Chinook salmon, and spring/summer Chinook salmon tend to show higher values than those for fall Chinook. With the small sample sizes of sockeye, these indices are difficult to determine with certainty; but they tend to be less than 1, thus indicating no benefit from juvenile transportation. Furthermore, survival estimates based on Chinook salmon and steelhead tagged upstream of Lower Granite Dam tend to be higher than estimates from fish tagged at that dam. Consequently, estimates of T:B and TIR ratios will also depend on where the fish were tagged.

The many factors involved in the CRS result in complex patterns and uncertain estimates of these transport to run-of-river ratios of survival.

Resolving how environmental conditions, ecological processes, and physiological/behavioral traits differentially affect transported and run-of-river migrants will help identify ways of implementing the transportation alternative strategy of “managed risk” (Corps 2015c). Disadvantages of juvenile transportation on survival can include lost opportunity to grow (Muir et al. 2006) and to smolt (Schreck et al. 2006) during the 2-day barge trip over a distance that would otherwise take at least two weeks for in-river migrants to pass. Other factors experienced by transported fishes include earlier timing of marine entry (Scheuerell et al. 2009; Holsman et al. 2012; Gosselin et al. 2018b), reduced thermal exposure (Gosselin and Anderson 2017), reduced total dissolved gas exposure (Brosnan et al.), increased disease (Eder et al. 2009; Dietrich et al. 2011), slower migration rate through the estuary (Dietrich et al.), stress on Chinook salmon when transported with steelhead (Sandford et al. 2012), and impaired imprinting that can result in adult straying (Keefer and Caudill 2014; Bond et al. 2017).

Furthermore, mark-recapture studies of acoustic tagged yearling Chinook through the hydrosystem and early marine environment found no substantial evidence of latent mortality differentials between transported and in-river migrants or for different numbers of powerhouses encountered (Rechisky et al. 2009; Rechisky et al. 2013; Rechisky et al. 2014). Notably the fish tagged were relatively large, due to tag technology at the time of the study and tag:body weight burden restrictions; results may be highlighting the possible significance of size in characterizing delayed effects. New acoustic tag technologies have significantly reduced tag: body weight burden challenges (e.g., 3 g tag in air in 2005 compared to 0.2 g tag in air, 2019) and will provide more valuable results in fish passage behavior the future.

The beneficial and detrimental effects of juvenile transportation depend on the species, stock, rear-type, timing, location, and environmental and fish conditions (Anderson et al. 2012). Some freshwater and marine covariates will be broadly relevant to delayed effects, and therefore relevant to both dam-route-specific survival and the effectiveness of juvenile transportation. Freshwater conditions (e.g., river velocity and temperature) and marine conditions (e.g., Pacific Decadal Oscillation index) respectively can exert delayed and direct influences on marine survival (Petrosky and Schaller 2010; Holsman et al. 2012; Haeseker 2014; Gosselin et al. 2018b). Complex interactions across the freshwater-marine environments can thus occur. One example involves migration timing, juvenile transportation, rear-type, and ocean conditions (Gosselin et al. 2018b). Another example of complex interactions involves smolt survival to below Bonneville Dam for Chinook salmon and steelhead (Elder et al. 2016); fishes that passed one or two dams were most influenced by water temperature, dissolved gas, outflow discharge, and atmospheric barometric pressure, while juvenile fishes passing three dams were most influenced by spillway discharge, fish velocity, and barometric pressure. The study also found that fish velocity had little effect on survival of Chinook salmon passing a single dam, while survival of juvenile Chinook salmon passing three dams was strongly negatively affected when fish travelled slower. Thus, delayed mortality may only occur with sufficient cumulative effects and certain interactions within and across the freshwater and marine environments.

Overall, delayed effects from passage routes and from juvenile transportation on ocean survival and adult returns can only be estimated by comparing smolt-to-adult survival of one group against another, and so the delayed effects are context specific. They depend on the selection and contrast of the two passage routes, the stocks, their condition and date entering and exiting the hydrosystem, the state of

the ocean during ocean entry, and the state of the ocean and hydrosystem during their adult residence and upstream migration. Because no study has accounted for all these factors, conclusions about delayed and latent mortality remain elusive. The best characterization of latent mortality comes from a target group that has lower smolt-to-adult survival than its reference group. Consequently, latent mortality may only occur during a portion of the migration season, for certain stocks, certain freshwater and marine conditions, and certain interaction effects.

Given the overall weight of evidence, it is uncertain to what extent CRS operations, as opposed to baseline or cumulative conditions, cause delayed mortality. As a result, the 2012 position from ISAB remains relevant. ISAB (2012) reviewed latent mortality associated with different routes of passage and indicated that the available evidence suggests that fish bypass systems are associated with some degree of latent mortality, but the magnitude and factors involved remained poorly understood. While Faulkner et al. (2019) found that fish size influences passage route—which could have confounded previous analyses that indicated passage at bypass systems resulted in lower adult return rates—there is still a need to better understand other conditions experienced during downstream passage that could result in delayed mortality.

3.1.1.4 Predation in the Columbia River Basin

Predation on juvenile and adult salmon and steelhead in the Columbia River Basin affects survival, distribution, and productivity by reducing abundance. Predation occurs above, within, and below the mainstem CRS projects. Birds and fish prey on juveniles as they migrate from tributaries through the mainstem to the estuary, while marine mammals prey on returning adults in the estuary, the Bonneville Dam tailrace, and even above Bonneville Dam (e.g., pinnipeds have been observed in the downstream area of The Dalles Dam). Various efforts are underway to mitigate the effects of predation on salmon viability. This section describes the three major groups of predators in the Columbia River Basin: fish, birds, and marine mammals. The effects of predation from these species on salmonid survival and recovery are significant. Cormorants, for example, are estimated to consume 20 million outmigrating salmonids per year. As explained below, however, the Action Agencies have undertaken efforts to reduce the effects of baseline predation as a means to offset potential negative effects of CRS operations.

FISH

The baseline effects of the existence of the CRS are believed to have increased piscivorous predation of salmonids in the following ways: increasing availability of habitats preferred by piscivorous fish by creating reservoirs (Faler et al. 1988; Beamesderfer 1992; Mesa and Olson 1993; Poe et al. 1994); increasing local water temperatures during mostly summer months, which increases piscivorous fish digestion and consumption rates (Falter 1969; Steigenberger and Larkin 1974; Beyer et al. 1988; Vigg and Burley 1991; Vigg et al. 1991); decreasing turbidity by capturing sediment, which increases predator capture efficiency (Gray and Rondorf 1986); and increasing stress and subclinical disease of juvenile salmonids, which could increase susceptibility to predation (Rieman et al. 1991; Gadomski et al. 1994; Mesa 1994). The main fish predators are northern pikeminnow (native), smallmouth bass (non-native), and walleye (non-native).

Northern pikeminnow

Based on the best available information, pikeminnow currently consume approximately 11 million out-migrating juvenile salmonids each year. Beamesderfer et al. (1996) estimated that northern pikeminnow consumed over 16 million total salmonids annually in the mainstem Columbia and Snake rivers prior to initiation of the Northern Pikeminnow Management Program in 1990 (NPMP; see below). However, total pikeminnow predation impacts are not evenly distributed throughout the Columbia and Snake rivers, but are instead concentrated in the lower Columbia River from The Dalles Reservoir downstream. Here, approximately 13 million of the 16.4 million total salmonids are estimated to have been consumed by northern pikeminnow. This estimated predation loss was 8% of the approximately 200 million hatchery and wild juvenile salmonids that were estimated to be migrating to the ocean.

In 1990, the Action Agencies began the NPMP to reduce predation by northern pikeminnow by removing fish at the dams and funding a sport reward program that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30%. Thus, based on the best available information, pikeminnow currently consume approximately 11 million out-migrating juvenile salmonids each year.

Smallmouth Bass

Smallmouth bass are another important predator of juvenile salmonids in the mainstem and some tributaries of the Columbia and Snake rivers. In the John Day Reservoir, smallmouth bass accounted for 9% of all salmon consumed by predatory fishes from 1983–1986 (Rieman et al. 1991). Juvenile salmon were found in 65% of smallmouth bass stomachs and composed 59% of the diet by weight between the Hanford Reach of the Columbia River and McNary Reservoir (Tabor et al. 1993). In the Snake River, Anglea (1997) reported that Chinook salmon composed 3.5% of smallmouth bass diets in the Lower Granite Dam Reservoir, and Naughton et al. (2004) found that salmonids composed 5–11% of smallmouth bass diets, depending on reservoir location.

In a recent study, Erhardt et al. (2018) found that total loss of juvenile Chinook salmon to smallmouth bass predation in Lower Granite Dam Reservoir has increased substantially since the mid-1990s, when the last predation study (Naughton et al. 2004) was conducted. Erhardt et al. (2018) sampled various parts of the Lower Granite Dam Reservoir and estimated that from 2013 to 2015, a total of over 300,000 juvenile Chinook salmon were consumed by smallmouth bass. Erhardt et al. (2018) concluded that the increase in predation rate in their study compared to Naughton et al. (2004) appears to be an increase in the consumption rate rather than an increase in smallmouth bass population.

Currently, there are no specific actions that are being made to reduce smallmouth bass predation in the Columbia and Snake rivers. However, recent changes to daily catch limits by the state of Washington (removal of daily limit) is meant to entice anglers to keep more smallmouth bass (and walleye), which could have the cumulative effect of reducing smallmouth bass predation on juvenile salmonids. The Corps is also seeking permits from the states of Washington and Oregon to take smallmouth bass when a bycatch of NPMP.

Walleye

Vigg et al. (1991) found that in the lower Columbia River, the salmonid component of walleye diets was highest in July and relatively high during May and August but low in April and June, concurrent with maximum temperature and abundance of juvenile salmonids. As judged by dietary composition and prey selectivity, walleye were much less important predators of salmonids in the John Day Reservoir than the much more abundant northern pikeminnow, which concentrated in the tailrace of the McNary Dam section of the John Day Reservoir (Poe et al. 1991; Vigg et al. 1991). However, in the John Day Reservoir, walleye and smallmouth bass appeared to select subyearling Chinook salmon in August when the distribution of this prey overlapped with that of the predators (Poe et al. 1991).

Beamesderfer and Nigro (1989) estimated that walleye annually consumed an average of 400,000 salmonids, or up to 2% of the salmonid run from 1983–1986. Abundance of walleye in the lower Columbia River appears highly variable, but losses of juveniles and smolts to walleye was estimated at up to 2 million fish per year, which compares to 4 million for pikeminnow (Tinus and Beamesderfer 1994).

Currently, there are no specific actions underway to reduce walleye predation in the Columbia and Snake rivers. However, recent changes to daily catch limits by the state of Washington (removal of daily limit) is meant to entice anglers to keep more walleye (and smallmouth bass), which could have the cumulative effect of reducing walleye predation on juvenile salmonids.

BIRDS

Since 1996, recoveries of PIT tags in piscivorous waterbird colonies have been used to calculate avian predation rates or probabilities (percentage or proportion of available fish consumed by birds). Studies have been conducted at colonies located throughout the Columbia River Basin. Since studies began in 1996, over 1.5 million PIT tags from 11 different fish species have been recovered in over 25 different piscivorous colonial waterbird breeding sites in the Columbia River Basin (Evans et al. In preparation). The main avian predators are Caspian terns, double-crested cormorants, California and ring-billed gulls, and American white pelicans.

Caspian terns

Roby et al. (2006) estimated that Caspian terns nesting on Rice Island in the estuary consumed about 12.4 million juvenile salmonids, or approximately 13% of the estimated 97 million out-migrating smolts that reached the estuary during the 1998 migration year. After these results were published, managers began actions to relocate the tern colony to East Sand Island, approximately 15 miles downstream and closer to the ocean and thus closer to a more diverse (non-salmonid) prey base. This resulted in a reduction in predation of juvenile salmonids by approximately five to six million fish annually. Since that time, management plans (see below) have been implemented, both in the estuary and inland, where Caspian terns are known to nest on islands on the mid-Columbia River and other various lakes and reservoirs (e.g., Potholes Reservoir, Banks Lake and more recently, Lake Lenore).

The Action Agencies have developed various plans to help minimize predation by birds. In 2005, the Caspian Tern Management Plan was approved (USFWS 2005), and in 2014, the Inland Avian Predation Management Plan (IAPMP) began (Corps 2014a). These plans have been successful in reducing avian

predation on certain runs of salmonids, especially steelhead (Evans et al. In preparation). Management actions have reduced the number of smolts eaten by birds (Figure 3-6.), although birds on the East Sand Island site still consume on average five million smolts per year (Roby et al. 2019). While management activities have reduced the size of the Caspian tern nesting colonies, the diet of Caspian terns in the estuary is still made up of a substantial portion of salmonids, more than 30% (Roby et al. 2019). However, most research performed in the estuary suggests that juvenile salmonids are less susceptible to predation by Caspian terns (and double-crested cormorants) nesting on East Sand Island than at colony locations within the freshwater zone of the Columbia River estuary, such as Rice Island (Cramer et al. In preparation).

For the IAPMP program, terns have successfully been moved away from previous nesting areas where management activities were undertaken. However, in some unmanaged colonies, predation rates appear to have risen (Collis et al. 2019).

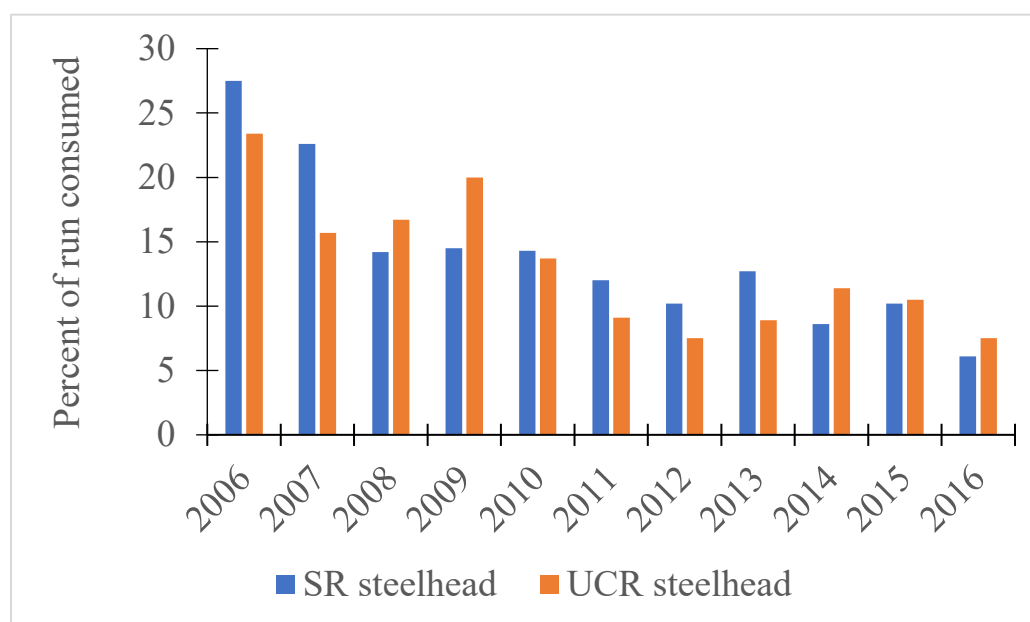


Figure 3-6. Annual predation rates on Snake River (SR) and upper Columbia River (UCR) steelhead from Caspian terns that nested on East Sand Island from 2006–2016 (Evans et al. 2018)

Double-crested cormorants

Overall, it is estimated that double-crested cormorants consume more smolts than Caspian terns. For example, from 2010–2012, Turecek et al. (2018) estimated that smolt consumption by double-crested cormorants (20 million fish) was about four times greater than that of Caspian terns during this same time period (five million fish). Predation rates of double-crested cormorants that have nested on East Sand Island have not shown the same steady decline in consumption rates as Caspian terns. Estimated predation rates by double-crested cormorants in 2018 were amongst the lowest ever recorded on East Sand Island, ranging from 0.4% (95% CRI = 0.1–1.0%) of MCR steelhead to 0.9% (95% CRI = 0.5–1.9%) of SR sockeye (Table 3-1).

Collectively, a combination of a smaller colony size and late colony formation resulted in some of the lowest East Sand Island cormorant predation rates observed since 2000; the first-year predation rate estimates are also available (Evans et al. 2016). Although predation from cormorants on East Sand Island has significantly declined, the colony has respectively moved upriver to the Astoria-Meglar Bridge. Predation impacts on juvenile salmon from this re-located colony are unknown.

Table 3-1. Average annual predation rates (95 percent credible intervals) by double-crested cormorants nesting on Eat Sand Island prior to and following management. Salmonid populations (ESU/DPS) with runs of spring (Sp), summer (Su), and fall (Fall) fish were evaluated, where applicable. NA denotes insufficient sample sizes of available fish. Asterisks denote statistically credible differences between management periods (see Methods).

Salmonid ESU/DPS	Pre-management Period (2003–2015)	Management Period ^a (2018)
Snake River (SR) Sockeye ^b	3.6% (2.7–4.5)	0.9% (0.4–1.7)*
SR Spr/Sum Chinook	5.2% (4.4–6.1)	0.5% (0.2–0.8)*
UCR Spr Chinook	3.1% (2.4–3.9)	0.6% (0.2–1.1)*
SR Fall Chinook	3.0% (2.6–3.6)	0.9% (0.5–1.5)*
Upper Willamette River Spr Chinook ^c	1.3% (0.5–1.8)	NA
SR Steelhead	9.3% (8.0–11.0)	0.5% (0.3–0.9)*
UCR Steelhead ^d	5.1% (4.1–6.1)	0.7% (0.4–1.3)*
MCR Steelhead ^e	8.3% (6.8–10.1)	0.4% (0.1–0.9)*

^a Predation rate estimates in 2016 and 2017 were not included in averages because cormorants dispersed from East Sand Island en masse during the peak smolt outmigration period and consumed an unknown percentage of tagged fish in those years (see also (Evans et al. 2018)).

^b Predation rate estimates were not available in 2000–2008 and in 2016–2017 due to insufficient sample sizes

^c Predation rate estimates were not available in 2000–2006 and in 2017 due to insufficient sample sizes

^d Predation rate estimates were not available in 2000–2002 due to insufficient sample sizes

^e Predation rate estimates were not available in 2000–2006 due to insufficient sample sizes

American White Pelicans

Evans et al. (2012) estimated predation rates on PIT-tagged salmonids by the Badger Island pelican colony and found to be the lowest observed among the nine bird colonies investigated during their study for years 2007–2010. Evans et al. (2012) summarized the potential reasons for the low rate of predation of juvenile salmonids by pelicans—a reliance on larger fish or on fish that congregate in shallow-water habitats and differences in foraging behavior that reduce the habitat overlap between Badger Island pelicans and outmigrating salmonids, or a combination of these factors. However, American white pelicans are often observed foraging in the tailraces of the mainstem dams, particularly at the McNary outfall and John Day tailrace. While diet information for pelicans foraging at the dams is limited, it is likely that they are foraging on at least some salmonids when present during spring periods.

California and Ring-billed Gulls

Smolt predation by gulls in the Columbia River can be substantial. For example, Evans et al. (2012) found that predation rates of gulls exceeded Caspian terns and double-crested cormorants. They postulated that high smolt predation probabilities for gulls were likely associated with relatively large colony sizes; gull colonies were an order of magnitude larger than those for Caspian terns, double-crested cormorants, and American white pelicans. Also, gulls seem to have behavioral flexibility to exploit temporarily available prey. Finally, another factor could be the proximity of some gull colonies to hydroelectric dams, where smolts may be particularly vulnerable to predation by gulls.

MARINE MAMMALS

Male California (*Zalophus californianus*) and Steller (*Eumetopias jubatus*) sea lions (and a few Harbor seals) feed on adult salmonids as they enter the Columbia River during upstream migration. Using the minimum numbers of pinnipeds observed at Bonneville Dam as an indicator of pinniped abundance, the minimum numbers from 2002 to 2018 fluctuated for California sea lions, Stellar sea lions, and Harbor seals—averaging annually 83, 43, and 1 individuals, respectively (Tidwell et al. 2019) (Figure 3-7).

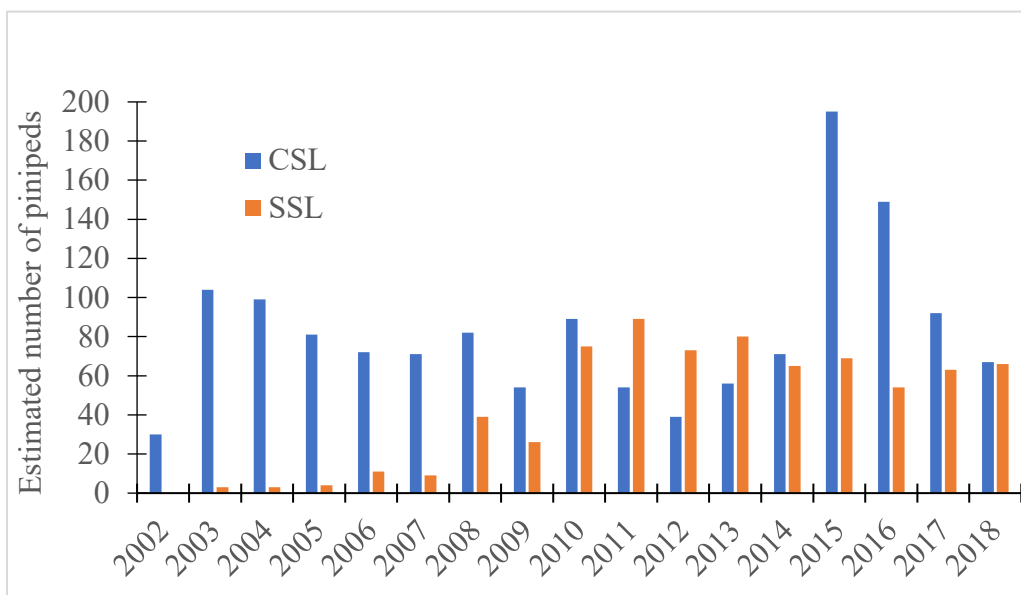


Figure 3-7. Expanded estimates (i.e., not accounting for unidentified fish catches) of pinniped predation on salmonids at Bonneville Dam, 1 January–31 May, 2002–2018 (Tidwell et al. 2019). CSL = California Sea Lion, SSL = Stellar Sea Lion.

Estimates of adult salmonid consumption by pinnipeds have ranged from less than 1% to 5.5%, averaging 2.6% from 2002 to 2018 (Tidwell et al. 2019) (Figure 3-8). In terms of each species, California sea lions have historically accounted for the most predation on adult salmonids, but Stellar sea lion numbers in the area have increased since the early 2000s (Figure 3-7) and continue to be a substantial source of mortality for salmonids and other species (e.g., white sturgeon and steelhead).

The Action Agencies have taken various actions to dissuade pinnipeds from consuming adult salmonids downstream of Bonneville Dam. In addition, lethal removal of a certain percentage of the sea lions is taking place, even though operation of the CRS does not cause pinniped predation. To limit the significant effects of this predation, other entities are lethally removing a certain percentage of the sea lions. Historically, some pinnipeds were relocated hundreds of miles away from the Columbia River, however some would eventually return to Bonneville Dam.

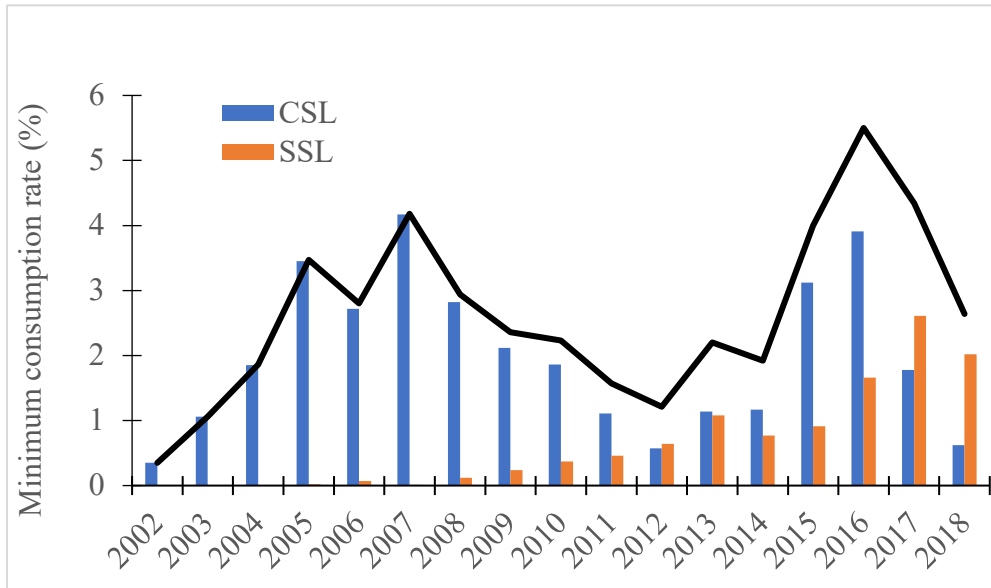


Figure 3-8. Estimated consumption of salmonids for the total salmonid run entering the Columbia River by California sea lions and Stellar sea lions from 2002 to 2018 (Tidwell et al. 2019). CSL = California Sea Lion, SSL = Stellar Sea Lion.

In their recent evaluation of pinniped predation at Bonneville Dam, Tidwell et al. (2019) concluded that there is apparent biological impact to listed steelhead, as well as a potential impact to listed chum salmon (and non-listed fall Chinook salmon) spawning downstream of Bonneville Dam. These findings demonstrate the impacts of effects prolonged residency and increased presence of regionally abundant Steller sea lions foraging near Bonneville Dam. It also supports the value of further examination of this dynamic. Deterrence measures currently employed are functional to keep pinnipeds out of the fish ladders and away from the fish ladder entrances when hazing is actively occurring.

However, actions to reduce predation immediately downstream of the fish ladder entrances have not been as successful. Upper Willamette River winter steelhead now also face the potential threat of pinniped-mediated extinction. The novel findings of Tidwell et al. (2019) illustrate that a similar pattern may be unfolding for select ESA-listed stocks at and around Bonneville Dam.

SUMMARY

Predation on juvenile and adult salmonids in the Columbia River Basin is a substantial source of salmonid mortality and is one of the factors preventing various populations of salmonids from achieving viability goals, although it is not an effect of CRS operations. Some programs the Action Agencies have

implemented have shown success in addressing this source of mortality, e.g., northern pikeminnow removal and dissuasion of Caspian tern nesting at Crescent Island, upstream of McNary Dam. Others have shown promise but need either changes or additional measures to be successful, e.g., sea lion hazing at Bonneville Dam. Additional monitoring and evaluation will assist in guiding the Action Agencies and co-managers to improving these programs.

3.1.1.5 Ocean Conditions and Anadromous Species

An expansive and diverse environment, the Pacific Ocean is critical to the life cycle of anadromous Columbia Basin salmonids, which can reside within the marine environment from less than a year to as many as five years. During their marine residence, they occupy areas of the continental shelf from northern California to the Gulf of Alaska and deep-water habitat beyond the continental shelf from British Columbia, Canada to the Kuril Islands of Japan. Given the extended marine residence and broad distribution of these fish, ocean conditions have a tremendous impact on their growth and survival. NMFS (2014a) discusses the ocean environment in detail, the processes and mechanisms affecting ocean conditions, and the interactions of Columbia Basin salmonids with the marine ecosystem. We incorporate that information here by reference, but offer the following as a brief synopsis of key points.

Ocean residence of salmonids often varies between species, stocks, origin (i.e., hatchery vs. natural spawners), and in some cases gender. For example, naturally produced UCR steelhead, both males and females, spend an average of 2 years in the ocean environment and between 1 to 4 years at sea. However, for hatchery-produced fish, males typically reside in the ocean for 1 year and females for 2 years (Chapman et al. 1994). For Snake River Basin steelhead, ocean residence varies between A- and B-Index fish, with A-Index steelhead typically residing in the ocean for 1 year and B-Index steelhead for 2 years (NMFS 2019). Finally, SR sockeye usually reside in the ocean for 2 years but can spend 1 to 2 years within the nearshore and open-ocean habitats (Bjornn et al. 1968; Farley Jr. et al. 2018).

Ocean distribution also varies by species and by year of residence. SR spring/summer yearling Chinook salmon typically spend about a day in the Columbia River plume (defined as rkm 8 to about 15 km south, west, and east of the Columbia River mouth), with earlier migrants spending on average about 2.2 days and later migrants 0.7 days (NMFS 2014a). Fish then usually disperse in all directions from the Columbia River mouth, but generally head north. Direction of migration once the fish leave the estuary appears to be driven by local conditions (wind and currents) and season. Regardless of the initial direction of migration, these fish typically remain on the continental shelf for the first year of ocean residence.

Based on trawl data, yearling Chinook salmon are usually found off the Washington coast in May, and by June or July have migrated north and are found from northwest Washington to southeast Alaska, being most abundant off the west coast of Vancouver Island and east of the Queen Charlotte Islands. By September, most of the yearling SR spring/summer Chinook have migrated north of the Northern California Current (Figure 3-9). Evidence based on otolith analysis suggests that the rate of northward migration is influenced by ocean conditions; when ocean conditions are poor, the rate of migration appears to increase (NMFS 2014a).

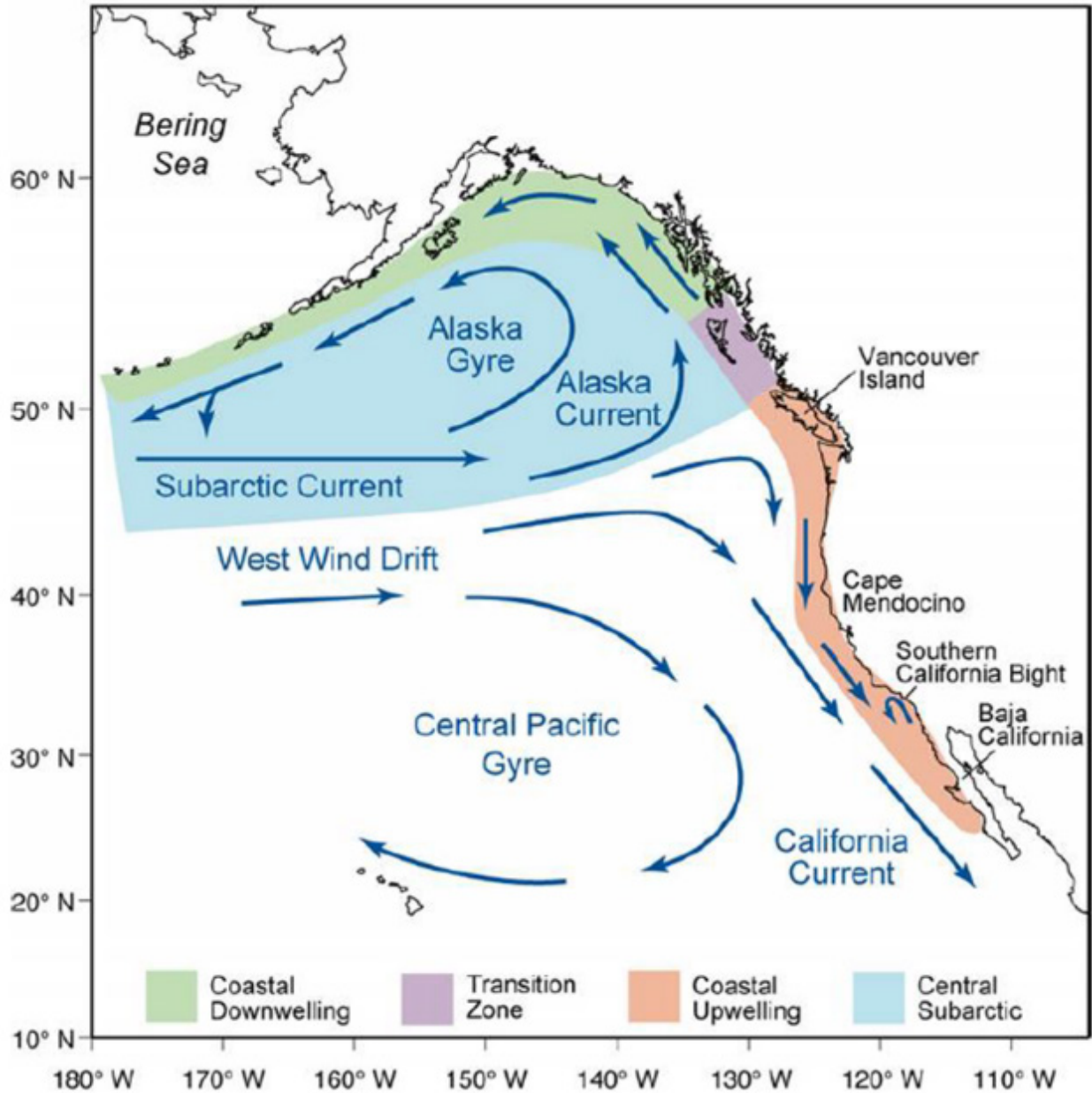


Figure 3-9. Schematic representation of the major current systems in the eastern Pacific. These are the major currents salmon from the Columbia River interact with. Figure reproduced from NMFS (2014a); Figure 4, page 11.

During their first ocean-year, SR yearling Chinook salmon continue migrating north to occupy the continental shelf from Central British Columbia to the Gulf of Alaska. By the beginning of their second year in the marine environment, they begin to move seaward away from the continental shelf into deeper water within the Gulf of Alaska (NMFS 2014a). After this point, little is known about the location of ocean residence or migratory habits for SR yearling Chinook. However, it is likely that they reside within the Gulf of Alaska until they begin to migrate back to their stream of origin (NMFS 2014a).

Most Columbia River Basin salmonids exhibit similar marine behavior with slight variations. Most species move rapidly through the Columbia River plume, spending the first year of marine residence on the continental shelf north of the Columbia River. The exception being SR steelhead, which move quickly away from the continental shelf (on average within 10 days). Most species migrate northward and eventually occupy areas beyond the continental shelf off the coast of British Columbia, Canada, to the Bering Sea, and in the case of SR steelhead, to the Kuril Islands of Japan.

Salmonid survival in the marine environment is driven by several environmental processes that primarily influence ocean water temperatures, upwelling, currents, and ultimately productivity of the food web that supports salmonid growth, health, and survival. For some populations of Columbia River Basin salmon, ocean mortality can exceed 95% and can be highly variable (NMFS 2014a). Some research suggests that the proportion of returning adults (smolt-to-adult ratio) is highly correlated to survival within the tidal freshwater, estuary, plume, and ocean habitats and is not related to in-river survival of the juveniles (Jacobson et al. 2012). These observations were based on estimates of smolt-to-adult ratios for yearling SR Chinook between the years 2000 and 2009 (NMFS 2014a).

There are several ocean conditions that have been linked to salmonid growth and survival. The largest is the Pacific Decadal Oscillation (PDO); other processes also contribute to ocean productivity, such as the Northern California Current (NCC), the North Pacific Gyre Oscillation (NPGO), the El Niño Southern Oscillation (ENSO), and climate change. The PDO is a large-scale circulation pattern that influences ocean temperatures and is itself influenced by a change in wind speed and direction. The PDO is measured based on variations in sea surface temperatures and is said to be generally in a cold or warm phase (Figure 3-10). The cold phase results from winds out of the north or north-northwest in the Gulf of Alaska during winter.

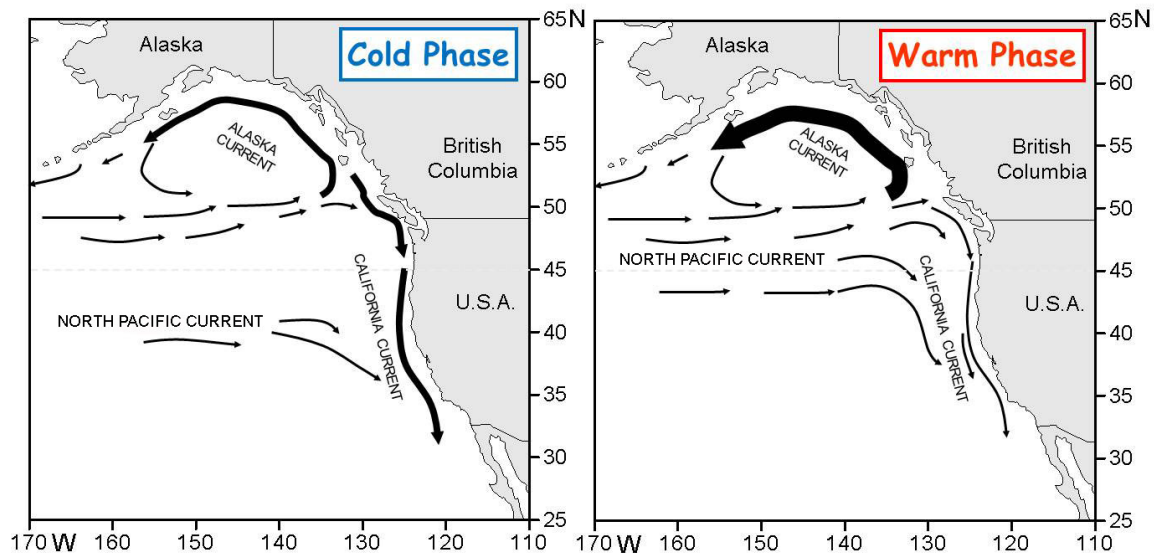


Figure 3-10. A working hypothesis on how changes in the Pacific Decadal Oscillation affect productivity in the Northern California Current. [Reproduced from NMFS (2014a); Figure 2.4-1.]

Cooler water temperatures of the cold phase are associated with increased primary and secondary productivity, leading to improved conditions for Columbia River salmonids. Copepod richness (the

average number of copepod species observed in plankton samples) is inversely related to copepod biomass. That is, as the number of observed copepod species increases, the overall copepod biomass decreases. The inverse of this is also true; as copepod biomass levels increase, copepod species diversity decreases. These trends are typically observed on a temporal scale, with greater species diversity observed during winter months and greater biomass observed during summer months (Figure 3-11).

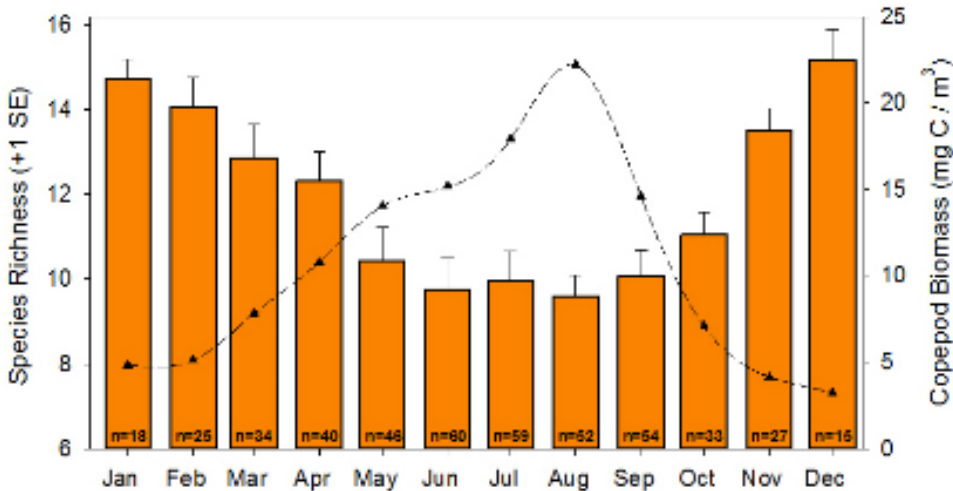


Figure 3-11. Vertical bars are the monthly averaged copepod species richness, a measure of biodiversity, at station NH-5 off Newport, Oregon. Dashed line with filled triangles is the monthly averaged copepod biomass (y-axis on right side of graph). Note the inverse relationship between copepod biodiversity and copepod biomass. Reproduced from Figure CB-01 from the NOAA website: <https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/ea-copepod-biodiversity.cfm#CB-02>.

During the warm phase, ocean productivity decreases, which results in worsened prey availability for Columbia River Basin fish. Historically, shifts between the cold and warm phases due to the PDO have occurred approximately every 20 to 30 years. However, more recently those phase shifts have occurred on the order of about every 5 years (Figure 3-12).

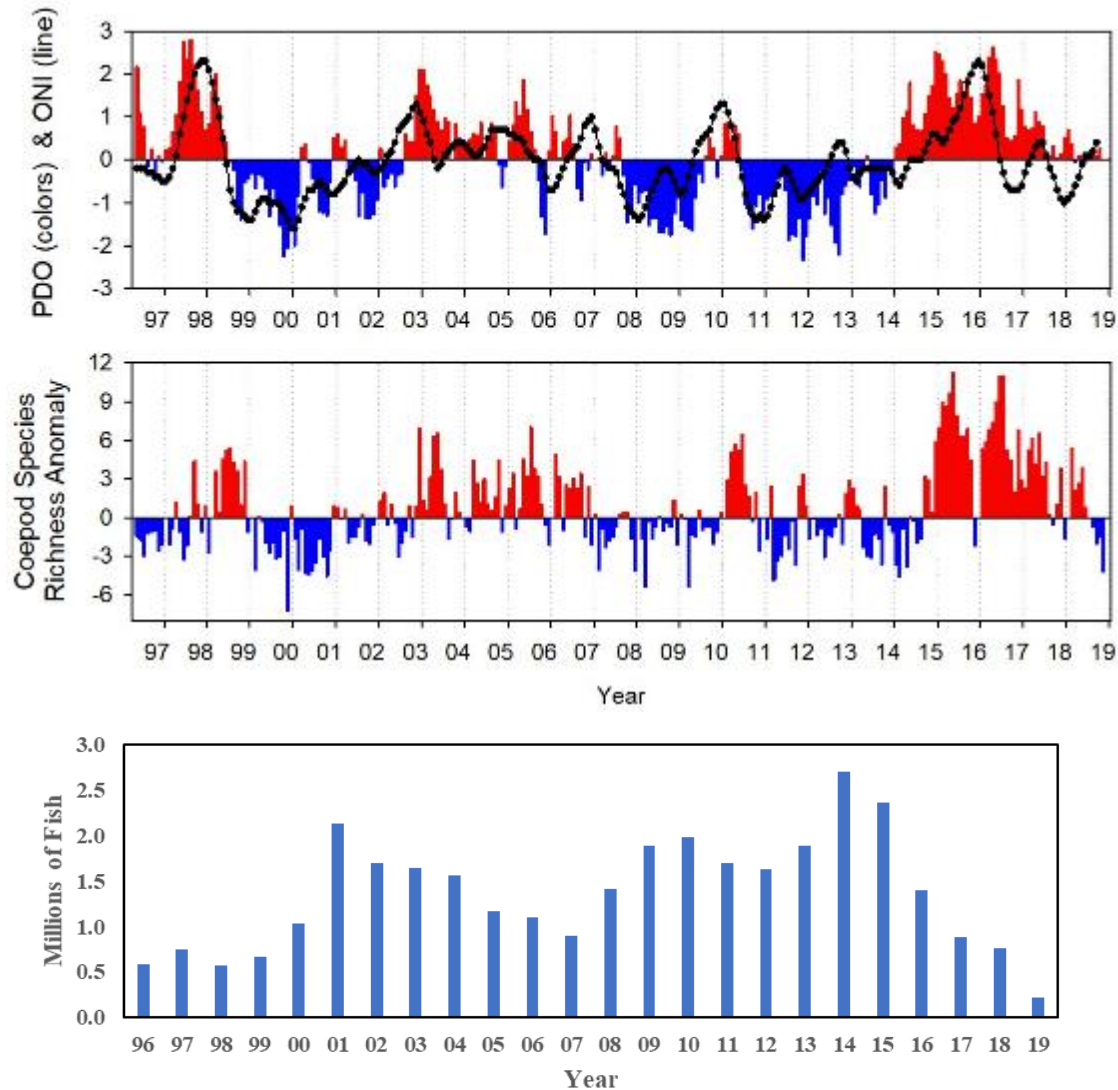


Figure 3-12. The upper graph shows a time series of the PDO (bars) and Ocean Niño Index (ONI; line) for the period of 1996 to the present. The middle graph shows anomalies in copepod species richness during the same period (Reproduced from NOAA Figure CB-02 - <https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/ea-copepod-biodiversity.cfm#CB-02>). The bottom graph shows annual adult salmonid counts at Bonneville Dam for the period of 1996 to the present (Data source: DART. Counts for 2019 are incomplete).

Inspection of Figure 3-12 reveals multiple relationships between the ONI, the PDO, copepod richness and biomass, and ultimately adult salmonid returns to Bonneville Dam. The top graph demonstrates that during the positive phase of the PDO, El Niño events (indicated by a positive ONI value), result in warm sea surface temperatures (red bars). Conversely, during a negative PDO phase, La Niña events (a negative ONI value), are associated with cooler sea surface temperatures (blue bars). These data also show that during La Niña events observed around 2000, 2009, and 2012, there were corresponding increases in copepod biomass and decreases in copepod diversity (richness). Increased copepod biomass also appears to be correlated with adult salmonid returns to Bonneville Dam. Subsequent to each

significant increase in copepod biomass, adult returns to Bonneville Dam 1 to 2 years later also increased (years 2001, 2010, and 2014). Based on their research, NOAA has concluded that salmon survival is inversely correlated to copepod richness, and that the copepod community at the time salmon first enter the ocean is a reasonably good indicator of adult salmon survival (Figure 3-13).²

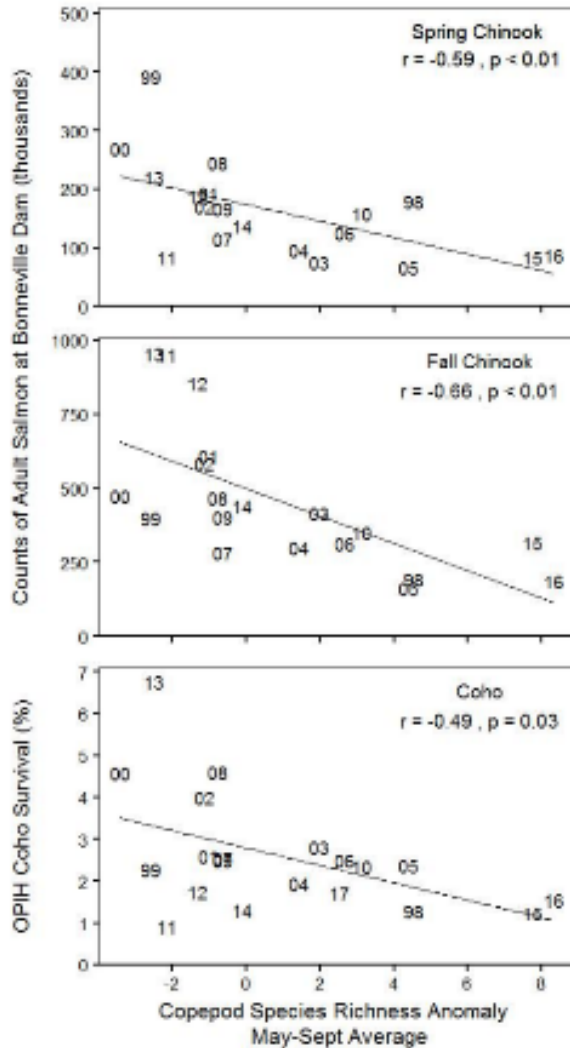


Figure 3-13. Relationship of spring and fall Chinook salmon adult returns to Bonneville Dam and coho salmon survival Oregon Production Index, Hatchery (OPIH) to the copepod species richness anomaly when these fish first entered the ocean 1 and 2 years prior (Chinook and coho salmon, respectively) from 1998–present. Number symbols indicate the year of juvenile salmon outmigration.

Tucker et al. (2015) assessed ocean distribution of SR sockeye and the effects of changing ocean conditions on adult returns. In their research, the authors concluded that ocean conditions, and by extension copepod biomass anomalies in the first year of ocean residence, contributed to the variability

² See the NOAA website <https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/ea-copepod-biodiversity.cfm#CB-02> for a detailed discussion on this topic.

of adult SR sockeye returning to Lower Granite Dam. Furthermore, adult returns were primarily affected by ocean conditions and to a lesser extent riverine conditions.

The NPGO is similar to the PDO in that it is a large-scale, wind-driven circulation process. Recent research suggests that it may account for oceanographic variation not explained by the PDO, such as low frequency variability of nutrients, chlorophyll, and oxygen levels (Di Lorenzo et al. 2008; Peterson et al. 2013). Other research indicates that the survival rates of coho and Chinook salmon since the 1980s along western North America can be explained by the NPGO rather than the PDO (Kilduff et al. 2015). Another process that influences regional ocean productivity is upwelling. This process occurs primarily from April through September, affects coastal waters along the continental shelf, and is driven by winds that blow from the north. These winds cause upwelling of nutrient-rich bottom water to the surface that in turn fuels primary and secondary productivity. This process can be affected by the PDO and is variable both spatially and temporally; upwelling can also vary based on El Niño and La Niña events. Water temperatures are warmer than normal during severe El Niño events, resulting in poor ocean productivity. Conversely, water temperatures are cooler than usual during La Niña events, resulting in favorable ocean productivity (NMFS 2014a).

It is anticipated that climate change will result in increased sea surface temperatures, but to what extent is uncertain. In model simulations assessing the PDO response to increasing CO₂ levels in the atmosphere, Fang et al. (2014) concluded that climate change will weaken the PDO and modulate it to a higher frequency. These conclusions comport with the findings of Zhang and Delworth (2016), where the effects of climate change on the PDO were evaluated using a fully coupled climate model. Those authors concluded that in response to climate change (global warming or cooling), the PDO would have a similar spatial pattern but the amplitude and time scale of variability would change. Specifically, during global warming the PDO amplitude would significantly decrease and the time scale would become shorter, changing from about a 20-year cycle to about a 12-year cycle. Conversely, during periods of global cooling the inverse would be observed (Zhang and Delworth 2016). There is also some evidence that climate change may alter the spatial distribution of some species. Many species that typically occur in more southerly waters migrated northward from southern California to Alaska during the unusually warm water conditions referred to as “The Blob” in 2014 and 2015. Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Pearcy (2002) and Fisher et al. (2015) as cited in NMFS (2019)].

In addition to becoming warmer, the world’s oceans are becoming more acidic as increased atmospheric CO₂ is absorbed by water. The North Pacific is already acidic relative to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Some research suggests that increased acidification may affect salmonids’ sense of smell, which is an important factor in navigation. Ocean acidification also negatively impacts invertebrates with calcium-based shells and exoskeletons, including zooplankton that juvenile salmon feed on.

3.1.1.6 Climate Change

Global climate change has the potential to have profound effects on the Columbia River Basin. Changes to air and water temperatures, snowpack, rainfall, runoff, streamflow, and a host of other short- and long-term ecological changes are possible. The Columbia River Basin and marine environments will likely be affected by climate change, and the resulting changes may impact listed salmon and steelhead during

all stages of their complex life cycles (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007a; NMFS 2019). Warmer conditions experienced in the Columbia River Basin will likely increase water temperatures, especially during the summer months when projected lower streamflows co-occur with projected warmer air temperatures. The effects of rising temperatures will likely indirectly affect streamflow and stream temperature patterns, in turn affecting spawning and rearing freshwater life stages of listed salmon and steelhead. Increased stream temperatures in freshwater environments would likely decrease the amount of suitable habitat available for rearing, potentially exacerbating a condition already limiting species viability. (NMFS 2019) indicated that 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 and uncertain.

The RMJOC long-term planning study serves as the basis for regional climate change effects projected on temperature, precipitation, snowpack, and streamflow (RMJOC 2018). The study presents the most recent and best available scientific information on the future hydroclimate for the Columbia River Basin. RMJOC (2018) found the following modeled trends for the 2020–2049 time period:

- Warming Trend—Warming in the region is likely to be greatest in the interior with a greater range of possible outcomes. Less pronounced warming is projected near the coast. Temperatures have already warmed about 1.5°F in the region since the 1970s and are expected to warm another 1°F to 4°F by the 2030s.
- Precipitation and Snowpack—Future precipitation trends are more uncertain, but a general increase in precipitation is likely for the rest of the 21st century, particularly in the winter months. Dry summers could already become drier. Average winter snowpack is likely to decline over time as more winter precipitation falls as rain instead of snow, especially on the United States portion of the Columbia River Basin.
- Hydrograph—By the 2030s, higher average fall and winter flows, earlier peak spring runoff, and longer periods of low summer flows are very likely. The earliest and greatest streamflow changes are likely to occur in the Snake River Basin, although this basin has the greatest modeling uncertainty.

Long-term predictions of climate change in the Pacific Northwest indicate an increase of 4°F to 13°F by the end of the century, with the largest increases expected in the summer (Mantua 2009; Mote et al. 2014). The warming rate for the Pacific Northwest over the next century is projected to be in the range of 0.2°F to 1.1°F per decade (NMFS 2019). Total precipitation changes are predicted to be minor (+1–2%) although increasing air temperature will alter the snowpack, streamflow timing and volume, and water temperature in the Columbia River Basin. According to the Fourth National Climate Assessment (USGCRP 2017), annual trends toward earlier spring melt and reduced snowpack are already affecting water resources in the western United States, and these trends are expected to continue. As a result of rising temperatures, other aspects of the climate are changing as well, such as receding glaciers, diminishing snow cover, shrinking sea ice, rising sea levels, and increasing atmospheric water vapor (USGCRP 2017).

(NMFS 2019) has indicated that the effects of climate change in marine environments include increased ocean temperature, stratification of the water column, ocean acidification, and possible changes in the

intensity and timing of coastal upwelling. In coastal areas, projections indicate an increase of 1–4 feet of global sea level rise by the end of the century. Sea level rise could erode or inundate tidal flats and coastal wetlands (Mote et al. 2014). Climate models reviewed by NMFS 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. Warm PDO phases result in decreased ocean productivity and, in turn, decreased salmonid growth and survival. (NMFS 2019) reported that hypoxic conditions observed in recent years along the continental shelf appear to be related to shifts in upwelling and wind patterns that may be related to climate change. The potential effects of climate change on coastal upwelling appear to differ regarding whether upwelling will decrease or intensify. Regardless, even if it does intensify, the increased stratification of the water column may reduce the ability of upwelling to bring nutrient-rich water to the surface. Climate-related changes in the marine environment are expected to alter primary and secondary productivity and the structure of marine communities, thus affecting growth and survival of salmon and steelhead that rely on estuarine and marine habitats.

As reported by NMFS (2019), climate change would affect salmon and steelhead and their critical habitat in the following ways:

- Projected warmer stream temperatures could increase pre-spawning mortality and cause a decrease in growth, development rates, and disease resistance.
- Changes in flow regimes (projected 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.
- Timing of smolt migration may change due to a modified timing of the spring freshet.
- Changing ocean conditions and marine food webs could affect ocean survival and growth.
- Projected sea level rise could cause significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007).

NMFS (2019) has indicated that management actions may help alleviate some of the potential adverse effects of climate change (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.). Many of the habitat improvement actions planned, designed, funded, and implemented by the Action Agencies will help support resilient habitats and species flexibility to climate change. For example, actions to enhance riparian areas, stream complexity, and streamflow will help mitigate the effects of projected warmer summer temperatures, climate-related changes in flow regimes, increased wildfires, changes in flood regimes, and increases in cumulative stress to stream systems. In conclusion, how climate change will actually affect salmon and steelhead is uncertain.

3.1.2 Snake River Salmonid Species

The Snake River salmonid species listed under the ESA are SR fall-run Chinook salmon (*Oncorhynchus tshawytscha*), SR sockeye salmon (*O. nerka*), Snake River Basin (SRB) steelhead (*O. mykiss*), and SR spring/summer-run Chinook salmon (*O. tshawytscha*). The Snake River has the largest drainage area of all tributaries to the Columbia River (~108,000 square miles). Its mouth near Pasco, Washington, is

about 325 RM from the Pacific Ocean. Moving upstream from the river's mouth, major blockages for anadromous fish passage occur at Hells Canyon Dam (Snake River mile 247) and Dworshak Dam (Clearwater River mile 1.2). Important tributaries for listed Snake River salmon and steelhead include the Clearwater, Grande Ronde, Imnaha, Salmon, and Tucannon Rivers.

3.1.2.1 Snake River Fall Chinook ESU

This section describes the status of the SR fall-run Chinook salmon ESU, its habitat, and the expected future baseline, cumulative, and action effects to this ESU.

STATUS OF THE SNAKE RIVER FALL-RUN CHINOOK ESU

SR fall-run Chinook (*O. tshawytscha*) were originally listed as threatened in 1992 (57 FR 14653). Threatened status was reaffirmed in 2005, 2010, and 2016 (Good et al. 2005; NMFS 2005; Ford 2011; NMFS 2016d).

The status of a species describes the species' potential for survival and recovery. It is based on an assessment of extinction risk and is a function of abundance, productivity, spatial structure, and diversity. Those parameters are, in part, included in listing decisions, status reviews, and recovery plans. The most recent status review (NWFSC (Northwest Fisheries Science Center) 2015) was informed by available updated abundance and hatchery contribution estimates provided by regional fishery managers. For the SR fall-run Chinook salmon population, estimates of productivity, diversity, and juvenile abundance, are difficult to obtain due to challenges in conducting surveys in the species' preferred spawning areas in the mainstem Snake River. Therefore, in their 2015 status review and the 2019 BiOp, NMFS used a set of metrics developed and recommended by the Interior Columbia Technical Recovery Team (ICTRT).

The most recent status review (NMFS 2016a) and BiOp discussion of this ESU's status (NMFS 2019) are incorporated here by reference. The following material briefly summarizes the current status of the SR fall-run Chinook salmon ESU.

The ESU includes all natural-origin fall-run Chinook salmon from the mainstem Snake River below Hells Canyon Dam (RM 247) and from the Tucannon, Grande Ronde, Imnaha, Salmon, and Clearwater River subbasins (NMFS 2017c). Fall Chinook salmon from four artificial hatchery programs are also included in the ESU: Lyons Ferry Hatchery Program, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery Program, and Oxbow Hatchery Program (64 FR 50406). The SR fall-run Chinook salmon ESU is composed of one extant MPG (NMFS 2019); Figure 3-14; Table 3-2).

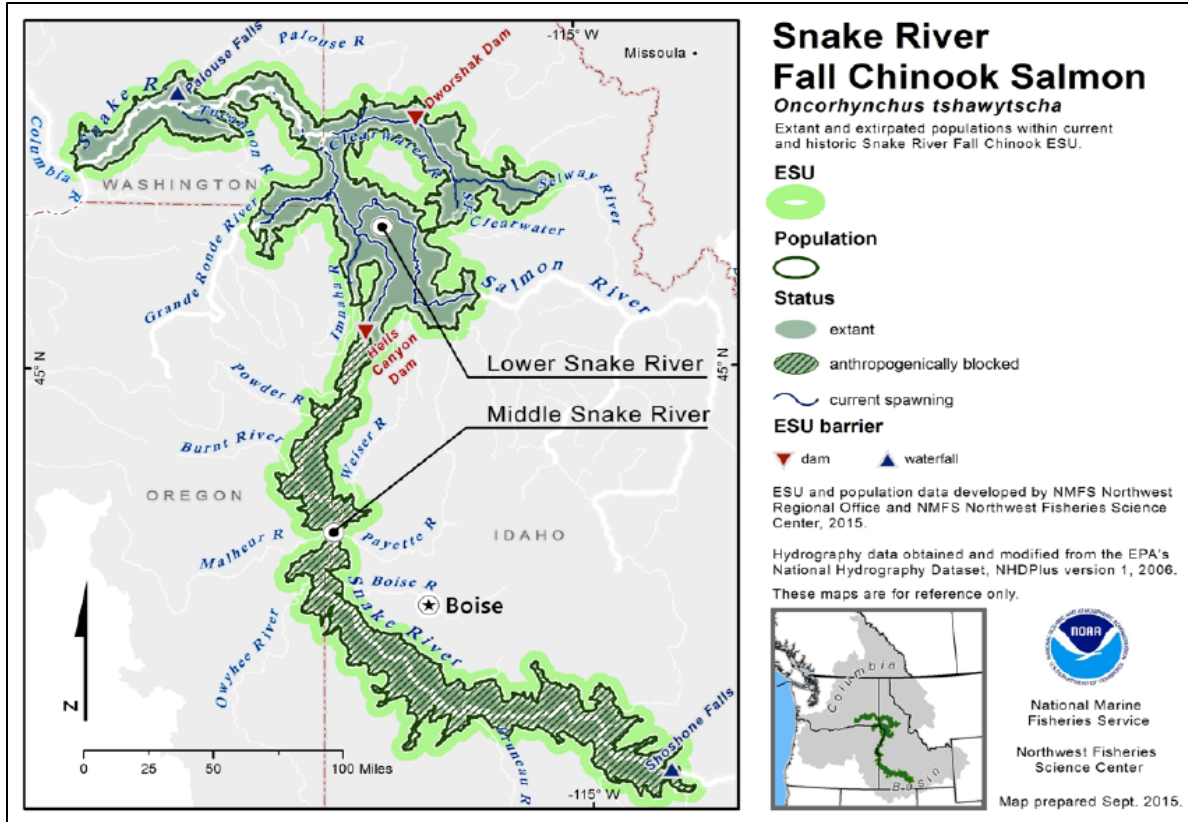


Figure 3-14. SR fall-run Chinook salmon ESU spawning and rearing areas [reproduced from NWFSC (Northwest Fisheries Science Center) (2016)]

Table 3-2. SR fall-run Chinook salmon major population groups and populations, as well as viability status (NMFS 2019)

Major Population Group	Populations	Status of Population (overall viability rating)
Natural Production		
Lower Snake River	Lower Mainstem Snake River	Viable
Artificial Production		
Hatchery Programs Included in ESU (n = 4)	Lyons Ferry Hatchery Program, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery Program, and Oxbow Hatchery Program	NA
Hatchery Programs Not Included in ESU (n = 0)	NA	NA

Due to improvements in the ESU’s estimated abundance and productivity, NMFS (2016a) recommended in the most recent 5-year status review that the overall viability risk rating for SR fall-run Chinook salmon should be reduced from moderate risk (i.e., maintained) to low risk (i.e., viable). This determination was based on a low risk rating for abundance/productivity and a moderate risk rating for spatial structure/diversity (NWFSC (Northwest Fisheries Science Center) 2015). NMFS (2019) concluded the following in their 2019 BiOp:

Overall, the abundance of SR fall Chinook salmon (including natural-origin fish) has increased substantially in recent years. Continued high levels of hatchery-origin spawners in natural spawning areas, and the potential for selective pressure imposed by current hydropower operations (yearling versus subyearling life history pattern) and cumulative harvest impacts contribute to the moderate risk rating for spatial structure/diversity.

FACTORS AFFECTING THE STATUS OF SNAKE RIVER FALL CHINOOK SALMON

Within the area of the lower Snake River and its tributaries that support spawning and rearing of the SR fall-run Chinook salmon population, a variety of factors affect both the species and their habitat. These factors include the development and operation of federal and private dams, land use practices, and other anthropogenic activities. Impacts include degraded tributary fish passage, floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, streamflow, and water quality (NMFS 2019).

With a decline in salmonid production and the subsequent decline in spawners within natal streams, the availability of nutrients vital to juvenile production have also decreased over the last century and a half. Gresh et al. (2000) estimated that, since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only about 6–7% of historical levels. They attributed the decline in salmonid production to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. Nutrients in streams are important for salmonid production (Bisson and Bilby 1998; Naiman et al. 2000).

Over a complete life cycle, the greatest incidence of mortality occurs in tributary and early-ocean environments (see Section 3.1.1.1, Figure 3-1). Tributary survival of juvenile fall Chinook salmon varies depending on habitat and climate conditions, as well as the carrying capacity of the natal stream (Thurrow 1987; Chapman et al. 1994). The average of smolt-to-adult return (SAR) ratio estimates for SR fall-run Chinook salmon (natural origin) at Lower Granite Dam over 2006, 2008, 2009, and 2011 was 1.7%. (The annual SAR estimates do not account for smolts that perish before reaching Lower Granite Dam). FPC (2018) estimated that survival from Lower Granite Dam to Bonneville Dam for natural-origin SR fall-run Chinook salmon has improved from 53.2% from 1992–2005 to 70.2% from 2008–2017. Discussion of factors affecting the status of SR fall-run Chinook salmon by life-stage follows.

Freshwater Spawning, Rearing, and Migration to the CRS

SR fall-run Chinook salmon use the mainstem Snake River and some tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. While many of the habitat modifications are relics of past anthropogenic practices, NMFS (2017c) identified several limiting habitat factors in these areas that continue to influence species viability and distribution. The factors included: (1) blocked access, (2) altered flows, (3) altered thermal regime, (4) reduced habitat complexity and floodplain connectivity, (5) increased sediments, (6) toxic pollutants, (7) degraded riparian conditions, (8) low dissolved oxygen, and 9) reduced habitat quantity and diversity.

As discussed in Section 3.1.13.1.1, the consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. The ISAB (2015) suggested that because habitat

capacity has been diminished there is an increased potential for density dependent factors affecting overall abundance and viability. As discussed in Section 3.1.13.1.1, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages for the populations they examined. Based on this evidence, they noted that due to density dependence during the parr-to-adult stage, a greater number of fish reaching the ocean may not substantially increase the number of adults reaching the spawning grounds. The authors thus concluded:

This suggests that life cycle modeling to date has been overly optimistic about the benefits of survival rate increases in the hydrosystem and elsewhere to improve the viability of salmon populations threatened with high extinction risk.

While the modeling framework of Hinrichsen and Paulsen (2019) was applied to SR spring/summer Chinook salmon, the results are consistent with the 2015 ISAB report. It is therefore reasonable to assume that SR fall-run Chinook salmon are also experiencing similar effects of density dependency.

Past and present effects of the existence of CRS dams and operations: For the portion of SR fall-run Chinook salmon that spawn in Snake River tributary environments, they are not directly exposed to the CRS facilities or operations during adult holding, spawning, egg incubation, or juvenile rearing and initial migration. However, SR fall-run Chinook salmon that spawn in the mainstem lower Snake River will continue to be directly affected by both the existence of CRS dams and CRS operations.

Past and present effects of hatcheries: Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They can also help preserve genetic resources until factors limiting natural productivity can be addressed. Existing hatchery programs for SR fall-run Chinook salmon appear to have increased abundance and spatial structure. NMFS (2017c), however, considering the amount of hatchery relative to natural-origin production, as well as the high proportion of hatchery-origin fish on the spawning grounds, to pose concerns regarding productivity; i.e., density dependence and diversity. In the 2019 BiOp, NMFS (2019) concluded that there are major uncertainties regarding the interactions and impacts of hatchery-origin fall Chinook salmon on natural-origin fish.

In the Proposed Action of this BA, the Action Agencies reiterate their continued funding support for the array of conservation hatchery programs throughout the Columbia River Basin related to CRS management.

Juvenile Fall Chinook Salmon Downstream Migration Through the CRS

Most fish of the one MPG for the SR fall-run Chinook salmon ESU originate upstream of Lower Granite Dam. Outmigrants and returning adults must pass eight CRS projects to and from the Pacific Ocean, respectively. The spawning aggregate in the Tucannon River, which enters the Snake River at RM 62, migrates through a total of six CRS projects as juveniles and adults.

Past and present effects of CRS existence and operations: Through the CRS, juvenile SR fall-run Chinook salmon have been and continue to be exposed to the effects of both CRS operations and the existence of the CRS dams. During downstream migration, outmigrants confront baseline migratory impediments in the dams. Because survival of fish passing the dams via non-turbine routes is generally higher than through turbines, passage facilities are designed and operated to increase the likelihood of juvenile fish

passage through non-turbine routes. The metric by which this is measured is referred to as Fish Passage Efficiency (FPE). Depending on the location, approximately 70 to 95 percent of juvenile SR fall-run Chinook salmon use these non-turbine routes at CRS dams (Table 3-3). They experience multiple possible passage routes, including spillways, surface passage structures, turbine intake screen bypass systems, and turbine units. At each dam, specific CRS operations support safe, non-turbine passage designed to limit the effects of turbine operations and to mitigate the passage impediments caused by the existence of the dams. Turbine units are also operated to minimize impacts on fish that pass through the powerhouse. Major structural modifications have been made to baseline conditions within the CRS to improve survival and achieve the 2008 BiOp juvenile dam passage performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project (Table 3-3).

A portion of the juvenile fall Chinook salmon are diverted away from turbine units and into a system of channels and flumes before delivering them to either the tailrace below the dam (bypassed) or, in the case of Lower Granite, Little Goose, and Lower Monumental Dams (collectively referred to as the collector projects), into raceways where they can be loaded onto barges and taken below Bonneville Dam (transported) where they are released to continue their migration to the ocean.

There are potential negative effects from transportation, such as higher rates of straying of returning adults that were transported as juveniles, which also may increase exposure to higher water temperatures. However, the average conversion rate (reach survival, adjusted for reported harvest and the expected rate of straying in an unmanaged system) of adult SR fall Chinook salmon transported as juveniles is about eight percent lower than for adults that migrated in-river as juveniles.

Table 3-3. Average fish passage efficiency (FPE) and dam passage survival estimates for hatchery-origin juvenile fall Chinook salmon passing CRS dams [based on Table D-2 from Bonneville et al. (2018b) and Corps et al. (2017a)]. FPE is calculated by dividing non-turbine passage by total project passage.

Dam	Year of Studies	FPE (%)	Year of Studies	Dam Passage Survival Estimate (%)
Bonneville	2012	69.7	2012	97.4
The Dalles	2012	78.4	2010, 2012	94.0, 94.5
John Day	2012	85.8	2012, 2014	91.3–94.1
McNary	2012, 2014	80.9, 90.9	2012, 2014	96.1, 97.5
Lower Monumental	2012, 2013	92.4, 95.1	2012	93.0, 97.9
Little Goose	2012, 2013	95.1, 95.0	2012, 2013	90.8, 95.1

Past modifications of the dams to improve baseline conditions include the installation of surface passage systems, improved turbine designs (at some dams), and upgrades of intake screen bypass systems to improve how and where fish are returned to the river downstream from dams. In addition, spill operations (amounts and patterns) tailored to the unique structural configuration of each dam have been instituted (Bonneville et al. 2018b). A summary of those improvements is provided in Appendix A of Bonneville et al. (2018b), and is incorporated by reference here. In addition to the actions described in Section 3.1.1 that affect all species, CRS actions that have improved SR fall-run Chinook salmon survival during the outmigrant life stage include:

- Change operations to minimize winter drafts of the large upper basin storage reservoirs (for FRM and power generation) to save water for augmenting spring flows during the peak juvenile passage period (water quantity).
- Construct JBSs and surface passage structures and provide spill at the run-of-river dams to divert smolts away from turbine units (safe passage) and reduce potential delay in the forebays.
- Install safer turbines for fish passage.
- Reduce TDG through multiple actions and plans.
- Manage avian and fish predators through multiple actions and plans.
- A factor affecting juvenile SR fall Chinook salmon life history and survival is the release of water from Dworshak Dam in the summer. Cool water has been released from Dworshak Dam since the mid-1990s in order 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 SR juvenile fall Chinook salmon 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.
- Using information from FPC (2018), NMFS (2019) estimated the average survival for hatchery-origin subyearling fall Chinook from Lower Granite Dam to McNary Dam—to be 53.2% for 1992–2005 and 70.2% for 2008–2017. The increased survival occurred after passage conditions were improved at Little Goose, and Lower Monumental. While no studies have been completed to infer what caused the increase in survival since 2009, the timeframe correlates to implementation of operational and structural modifications undertaken specifically to improve downstream survival. The increased survival since 2009 suggests that those structural and operations changes at the dams are benefiting SR fall-run Chinook salmon.

In addition, TDG levels affect water quality in the mainstem Columbia and Snake Rivers. Atmospheric gases can get forced into solution when water passes over the spillway at a dam, either as a consequence of CRS operations or involuntarily due to high inflows, causing supersaturation in water flowing downstream. Supersaturated TDG conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway flow deflector structures at each mainstem dam. Those structures reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019).

Past and present effects of predator management: Survival of juvenile SR fall-run Chinook salmon is decreased by avian and native and non-native fish predators that inhabit the mainstem Columbia and Snake Rivers. The 2008 FCRPS BiOp, as supplemented in 2010 and 2014, recommended that the Action Agencies implement multiple predation control measures to increase survival. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019).

Juvenile Fall Chinook Salmon Estuary Migration and Rearing, Including the Plume

The estuary provides important habitat for SR fall-run Chinook salmon populations. Since the late 1800s, 68% to 70% of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also impacted estuary ecosystems. The effects of all of these conditions are part of the environmental baseline.

Past and present effects of CRS existence and operations: While there are no CRS facilities in the estuary, the existence and past operations of CRS dams affects the timing and volume of flows, as well as TDG levels in this area. However, the influence of CRS dams and operations on the estuary and plume is generally attenuated below Longview, WA, due to distance from the dams, inflow from other tributaries joining the Columbia River, and multiple other dams and diversions within the basin that also affect flows and water quality in the estuary. The reduction in flows and associated sediment recruitment downstream from Bonneville Dam has likely limited some downstream habitat forming processes from occurring.

To help improve baseline conditions and thus maintain and/or improve the overall status of salmon and steelhead in the Columbia River Basin, the Action Agencies actively work to restore and conserve habitat in the Columbia River estuary through CEERP. These restoration actions affect salmon directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit of estuary restoration is that wetland food production supports foraging and growth within the wetland [Johnson et al. (2018) as cited in NMFS (2019)]. Prey items (primarily chironomid insects and corophiid amphipods; [PNNL/NMFS (2018) as cited in NMFS (2019)] produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest five-year review of the CEERP, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide-gate upgrades (887 acres). These projects represented a 2.5% net increase in floodplain connectivity below Bonneville Dam [Johnson et al. (2018) as cited in NMFS (2019)]. In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past and present effects of predation management: A variety of avian species (especially Caspian terns and double-crested cormorants), have historically been a major source of predation on juvenile salmonids in the estuary. While this predation continues, including on SR fall-run Chinook salmon, predation rates have declined due to a variety of management efforts. For example, between 2007 and 2010, the average predation on SR fall-run Chinook salmon by Caspian terns and double-crested cormorants from East Sand Island (near the mouth of the Columbia River) was approximately 2.5% and 3%, respectively (Evans et al. 2018). However, from 2011 to 2017 (2003–2015 for cormorants), the average for Caspian terns dropped to 0.8%, and 0% for double-crested cormorants (for years 2016–2017) (Evans et al. 2018). Although predation impacts from Double-crested cormorants on East Sand

Island has significantly declined, some predation may be occurring at newly formed or growing colonies in the estuary, for example, on the Astoria-Meglar Bridge. The efforts to reduce avian predation are discussed in detail within the 2019 BiOp and are incorporated by reference here (NMFS 2019). NMFS (2019) noted some success of avian management plans at meeting underlying goals of reducing predation on juvenile salmonids.

Ocean Rearing

The length of ocean residence for SR fall-run Chinook salmon is typically 2 to 5 years depending on sex and age at the time of ocean entry (NMFS 2017c). Since about 2014, relatively poor ocean conditions have contributed to declines in ocean survival and associated adult returns. In the 2019 BiOp, NMFS provides a detailed discussion on ocean conditions, factors that affect the ocean environment, and impacts to SR fall-run Chinook salmon. That information is incorporated here by reference; a brief summary follows.

Factors that influence ocean productivity likely affect survival of fall Chinook salmon. The projected increase in air temperature due to climate change will likely increase water temperature and alter productivity, increase the frequency of severe El Niño events, worsen ocean acidification, and cause major alterations in the northeast Pacific Ocean marine ecosystem associated with the Pacific Decadal Oscillation (PDO) (NMFS 2019). This will affect survival either directly or indirectly because of the deleterious impacts on marine food webs.

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in the distribution of aquatic marine organisms. Many species that typically occur in more southerly waters moved northward from southern California to Alaska in the unusually warm water during 2014 and 2015, which was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Pearcy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt marine ecosystems in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean, and past CRS operations have had no direct effect on this ESU during ocean residence. In a recent review, Welch et al. (2018) concluded that marine survival of West Coast Chinook and fall Chinook salmon populations has collapsed over the last half century for most regions of the West Coast. Based on their review of annual survival estimates for Chinook and fall Chinook salmon, they concluded the following:

We found that marine survival collapsed over the past half century by a factor of at least 4-5-fold to similar low levels (~1%) for most regions of the west coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Another factor to consider in this stage of the life cycle is delayed, or latent, mortality. Delayed mortality is a term for harm caused when an animal survives one event or circumstance but incurs damage that only shows up later and may be expressed as illness or death. With Columbia River Basin salmon and fall

Chinook salmon, the term is commonly applied in situations such as barging or dam passage of salmon or fall Chinook salmon smolts. The term “latent mortality” is generally used more specifically to apply to the effects of dam passage. While most or all of the fish might survive the act of barging or migrating in-river past the dam, the delayed mortality hypothesis holds that, as a result of passing a dam, a smolt is less healthy than it would be otherwise and is therefore less likely to survive in the ocean and return as an adult (see juvenile outmigration section in common factors).

ISAB (2012) concluded, after reviewing various studies, that their analyses demonstrated that fish bypass systems seem to be associated with some latent mortality, although factors responsible for latent mortality remain poorly understood and inadequately evaluated. Furthermore, it was stated that the significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis).

Past and present effects of harvest: SR fall-run Chinook salmon are harvested in ocean and freshwater fisheries. They are caught off the coasts of southeast Alaska to California (NMFS 2017c, 2019) and in the Columbia River during fall fisheries both upstream and downstream of Bonneville Dam. The Pacific Salmon Commission Chinook Technical Committee (CTC) estimates total exploitation rates (percentage of fish harvested out of the total run) for SR fall-run Chinook salmon based on analysis of coded-wire tag recoveries for subyearling releases of Lyons Ferry hatchery fish. Average total exploitation rates for these fish were 70% during 1989–1992 and 46% during 2003–2012. (There were too few tag recoveries during the intervening years to conduct the necessary analysis). Since 1996, ocean fisheries have been required through ESA consultation to achieve a 30% reduction in the average exploitation rate observed during the 1988 to 1993 period (NMFS 2017c). Since 2008, the exploitation rate has been variable, averaging 37.2%. Total exploitation rates have ranged from 40% to 50% since the early 1990s (NMFS 2017c, 2019). This environmental baseline condition significantly influences the number of adult SR fall-run Chinook salmon surviving to spawn.

Adult Fall Chinook Salmon Migration to Bonneville Dam

Adult fall Chinook salmon migrating upstream after ocean residence typically do not feed within the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume and a migratory corridor free of obstructions to access spawning areas (NMFS 2019). Adult SR fall-run Chinook salmon enter the Columbia River estuary and pass Bonneville Dam between mid-August and the end of September (NMFS 2017c).

For upstream migrating SR fall-run Chinook salmon, the primary factor affecting survival to Bonneville Dam is pinniped predation. Estimates of pinniped predation downstream of the Bonneville Dam tailrace are not available for adult fall Chinook salmon, although salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2017c, 2019). The ODFW has documented an increase in monthly counts of California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, during the month of September. For the years 2008 to 2014, the number of California sea lions observed averaged less than 500 animals; for 2015 and 2016, that average increased to more than 1,000 individuals (NMFS 2019).

The abundance of pinnipeds in the Bonneville Dam tailrace has increased over the course of the last 6 years (Tidwell et al. 2019). In 2017, for the fall and winter observation period (August 15–December 31), an average of 14.5 Stellar sea lions were observed per day, and on numerous occasions more than 20 individuals were observed (Tidwell et al. 2019). The estimated consumption rate of Chinook salmon was 0.7% of the total Chinook salmon run. Adult Chinook salmon returning at this time period are made up of various stocks from the lower Columbia River, the Columbia River upstream of the confluence with the Snake River (which includes the Hanford Reach), and the Snake River. However, the 0.7% mortality rate serves as a reasonable, conservative estimate for SR fall-run Chinook salmon (NMFS 2019).

Past and present effects of CRS dams and operations: There are no CRS dams or operations that impede migration in the lower Columbia River as these fish migrate upstream to Bonneville Dam. As previously mentioned, adult SR fall-run Chinook salmon enter the Columbia River from mid-August to end of September, and the Action Agencies spill water over the CRS dams to increase survival of juvenile fish migrating downstream during a portion of that time. As such, adults may be exposed to higher levels of TDG, which may influence their migration behavior or increase their chances of GBT (NMFS 2019). TDG levels are mitigated to some extent downstream from Bonneville Dam due to gas dissipation and to mixing of water with lower TDG levels from tributaries such as the Willamette River.

Past and present effects of harvest: SR fall-run Chinook salmon have been harvested in both non-treaty commercial fisheries and in recreational fisheries in the area downstream of Bonneville Dam to the mouth. In fall fisheries, SR fall-run Chinook salmon are caught in the Columbia River mainstem and tributaries. Since 2012, SR fall-run Chinook salmon have been managed subject to an abundance rate schedule for a total exploitation rate (which includes ocean catch) that ranges from 30 to 41 percent. Recent total exploitation rates have been highly variable, but have averaged 37.2 percent since 2008. Total exploitation rates have ranged between about 40 and 50 percent since the early 1990s (NMFS 2019).

Adult Fall Chinook Salmon Migration through CRS Dams

SR fall-run Chinook salmon migrate upstream past six to eight lower Columbia and Snake River CRS projects on their way to natal spawning areas. During upstream migration in general, these fish experience a variety of factors that affect the adult migration life stage, including harvest; dam passage; straying; fallback (passing back downstream through a dam after exiting into the forebay from a fish ladder); predation from pinnipeds; and temperature and flow conditions that can increase the energetic demands of migrating fish [NMFS (2008b, 2008d); Keefer et al. (2016); and Keefer and Caudill (2017) as cited in NMFS (2019)]. Specific factors influencing safe, timely, and effective adult upstream passage through CRS dams are tailrace flow dynamics, attraction flows to fish ladder entrances, ladder operations to maintain safe temperatures, and project operations to reduce fallback (NMFS 2019). Focusing on these factors, the Action Agencies operate the CRS to provide safe and conducive passage conditions, thereby mitigating the baseline migratory impediments caused by the existence of the dams.

Past and present effects of CRS existence and operations: Under typical conditions, after accounting for reported harvest rates and expected stray rates, adult SR fall-run Chinook salmon have reasonably high

conversion rates³ passing the lower Columbia River and Snake River CRS dams (NMFS 2019). For adult SR fall-run Chinook salmon, the 9-year average conversion rate from Bonneville to Lower Granite Dams was 90.8% (range of 80.2% to 100.9%). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 98.6% per project (NMFS 2019). These estimates of minimum survival also account for impacts associated with fallback at CRS projects, such as direct and indirect mortality associated with the fallback event, delay, straying, elevated stream temperatures, and injuries from pinniped attacks downstream of Bonneville Dam. Put differently, these survival rates have been a function of both environmental baseline conditions and the effects of CRS operations.

The mean annual fallback rates for adult SR fall-run Chinook salmon at the lower Columbia River dams has been estimated to be 11.6 percent over 4 years of study from 1998 to 2002 for the CRS dams on the lower Columbia and Snake Rivers (Keefer et al. 2004). Based on the relatively high survival estimates, NMFS concluded that upstream passage conditions for adult SR fall-run Chinook salmon are not substantially impaired as fish migrate through the lower Columbia and Snake Rivers (NMFS 2019).

As discussed above, water is released from Dworshak Dam in the summer to reduce temperatures in the Snake River to reduce potential negative effects of increased water temperature on upstream migrating adult salmon and steelhead. These ongoing cool-water releases have improved late summer migration conditions for adult fall Chinook salmon in the Snake River (compared to historical conditions).

Past and present effects of predator management: As discussed previously, the presence of pinniped predators has increased within the Bonneville Dam tailrace and near the mouth of the Columbia River in recent years (Tidwell et al. 2019).

Average pinniped impacts to migrating adult SR fall-run Chinook salmon are likely relatively small because pinniped counts at Bonneville Dam are generally low in July and August (when most SR fall-run Chinook salmon pass Bonneville Dam), and they are mixed with relatively abundant Hanford Reach fall Chinook salmon migrating in September and October (NMFS 2019).

Past and present effects of harvest: Fall Chinook salmon in the lower Columbia River are primarily harvested during what managers term the “fall season.” During the fall management period, fisheries target primarily harvestable hatchery and natural-origin steelhead and coho salmon, as well as hatchery fall Chinook salmon. Fall season fisheries are constrained by specific ESA-related harvest rate limits for listed SR fall-run Chinook salmon, and both A-Index and B-Index components of the listed UCR and SR steelhead DPSs.

The allowable harvest rate ranges from 21.5 to 45.0 percent of the total fall Chinook run (NMFS 2018b). Since 2008, the overall harvest rate on SR natural-origin Chinook salmon has averaged 11.4 percent in non-treaty fisheries and 21.6 percent in treaty Indian fisheries [TAC (2017) as cited in NMFS (2018b)]. The mix between the two fisheries may vary so long as the total harvest rate does not exceed the year-specific maximum set by fisheries managers, which has ranged annually from 17.5 to 32.0 percent since

³ Conversion rates are simply the percentage of adult salmonids passing an upstream dam that passed a downstream dam ($\frac{\# \text{ passing}_{\text{upstream dam}}}{\# \text{ passing}_{\text{downstream dam}}}$). Conversion rate is used as a *surrogate* for the survival rate. Factors other than mortality may affect the number of adult fish passing the upstream dam (e.g., tag not detected). Conversion rate can be interpreted as a minimum survival rate.

2008. The 2018 United States v. Oregon Management Agreement (U.S. v. Oregon 2018), which provides the current framework for managing fisheries and hatchery programs in much of the Columbia River Basin, states that fisheries affecting SR fall-run Chinook salmon will be managed using the agreed abundance-based harvest rate schedule for what the parties to U.S. v. Oregon refer to as Upriver Bright stock. The harvest rate uses a “sliding scale” approach, where the rate depends on the estimated abundance of unlisted upriver fall Chinook and natural-origin SR fall-run Chinook salmon.

Migration Upstream of the CRS to the Spawning Areas

Within the Snake River mainstem and tributaries that support the spawning and rearing of SR fall-run Chinook salmon spawning aggregates, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation; e.g., agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (1) impaired fish passage; (2) reduced stream complexity and channel structure; (3) excess fine sediment; (4) elevated summer water temperature; (5) diminished streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

Low flows and high summer temperatures in the mainstem Snake River and associated tributary habitats can effectively create temporary migration barriers that reduce access to spawning habitat until conditions improve. Such water quality conditions can affect the run timing and survival to natal spawning areas for adult SR fall-run Chinook salmon.

Recreational fisheries for fall Chinook salmon in SR tributaries and mainstem Snake River upstream of the CRS result in incidental impacts to natural-origin fish to some unknown degree. Of the fish that are caught and released, it is assumed that 10% will die from handling related injuries (NMFS 2019).

STATUS OF CRITICAL HABITAT

In this section of the BA, the status of critical habitat for SR fall-run Chinook salmon is reviewed, and factors affecting the status of critical habitat are discussed. Critical habitat includes stream channels within designated stream reaches and to the extent defined by the ordinary high-water mark (33 CFR § 319.11). The physical and biological features (PBFs) of critical habitat that are essential to the conservation of SR fall-run Chinook salmon have been identified and include freshwater spawning, rearing and migration corridors, and estuarine and nearshore marine areas (Table 3-4) (NMFS 2019). The PBFs of critical habitat and climate change effects are presented in this section.

Table 3-4. Physical and biological features, as well as associated components and principal factors affecting the environmental baseline of critical habitat designated for SR fall-run Chinook salmon [based on NMFS (2019); Table 2.12-6]

Physical and Biological Feature (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs in the Action Area
Freshwater spawning sites	Spawning gravel Water quality Water quantity Food Riparian vegetation Space	<p style="text-align: center;">LOWER CLEARWATER RIVER</p> <p>Urban and rural development, forest and agricultural practices, and channel manipulations have reduced habitat complexity and floodplain connectivity (spawning gravel, food, riparian vegetation, and space)</p> <p>Forest and agricultural practices, including road building, have led to excessive sediment in spawning gravel (spawning gravel and space)</p> <p>Due to its thermal inertia, Dworshak Dam releases warmer water during the winter spawning and incubation periods (water quality)</p> <p>Spill events associated with flood risk management operations at Dworshak Dam and/or turbine outages periodically elevate TDG levels over incubating redds (water quality)</p> <p>Cool-water releases from Dworshak Dam during the late-June or early-July to mid-September rearing periods slow juvenile development (water quality)</p> <p>Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in areas used for spawning and rearing (water quality)</p> <p style="text-align: center;">HELLS CANYON REACH OF THE LOWER SNAKE RIVER</p> <p>Stabilization of outflow at Hells Canyon Dam has produced high-quality spawning and rearing habitat in the downstream reach</p> <p style="text-align: center;">LOWER SNAKE RIVER RESERVOIRS</p> <p>Inundated spawning habitat (space)</p> <p>Forest and agricultural practices, including road building, have led to excessive sediment in spawning gravel (spawning gravel and space)</p> <p>Inundated rearing habitat (food, riparian vegetation, and space)</p> <p>Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in areas used for spawning and rearing (water quality)</p> <p>Due to its thermal inertia, Dworshak Dam releases warmer water during the winter spawning and incubation periods (water quality)</p>

Physical and Biological Feature (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs in the Action Area
Juvenile migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food Riparian vegetation Space Safe passage	Impaired passage conditions at mainstem CRS dams reduce survival and cause injuries and stress; slower-moving reservoirs increase travel time and exposure to predators; increased risk of predation in forebay and tailrace areas (safe passage) Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in juvenile migration corridors (water quality) Construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting has created increased opportunities for avian predators (safe passage) Diking off areas of the estuary floodplain, combined with water diversions and water storage and hydroelectric projects that reduce peak spring and early summer flows, has reduced the productivity of floodplain habitats below Bonneville Dam (food)
Adult migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Riparian vegetation Space Safe passage	Impaired passage conditions due to effort expended finding fish ladders, temperature-related delays that sometimes block upstream migration, increased risk of pinniped predation, and increased risk of fallback (safe passage) Water withdrawals, reservoir storage and release operations, and thermal inertia of reservoirs contribute to increased late summer temperatures (water temperature). Projected increased air temperature from climate change may also contribute to increased water temperature Risky passage opportunities for adult Chinook salmon in the Bonneville Dam tailrace due to presence of pinnipeds Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in juvenile migration corridors (water quality)
Adult migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Riparian vegetation Space Safe passage	Impaired passage conditions due to effort expended finding fish ladders, temperature-related delays that sometimes block upstream migration, increased risk of pinniped predation, and increased risk of fallback (safe passage) Water withdrawals, reservoir storage and release operations, and thermal inertia of reservoirs contribute to increased late summer temperatures (water temperature). Projected increased air temperature from climate change may also contribute to increased water temperature Risky passage opportunities for adult Chinook salmon in the Bonneville Dam tailrace due to presence of pinnipeds Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in juvenile migration corridors (water quality)

Critical habitat for the SR fall-run Chinook salmon ESU was designated on December 28, 1993 (58 FR 68543). NMFS (2017c) designated critical habitat to consist of all Columbia River estuarine areas, river

reaches upstream to the confluence of the Columbia and Snake Rivers, and all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam. It also includes the following watersheds (not the entire watersheds—mostly the lower sections): Clearwater River, North Fork Clearwater River, Imnaha River, lower Grande Ronde River, lower North Fork Clearwater, lower Salmon, lower Snake, lower Asotin Creek, lower Tucannon River, and the Palouse River.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs.

As discussed previously, adult SR fall-run Chinook salmon enter the Columbia River estuary in August and September and pass Bonneville Dam from mid-August to the end of September with a median passage time of mid-September (NMFS 2017c). During their freshwater migration, adult salmon require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing and water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2019).

SR fall-run Chinook spawn in gravel and cobble substrates that are largely free of fine sediments. Developing eggs require cool, clean, and well-oxygenated waters for proper development. Juvenile fish emerge from eggs in the stream bed in late winter and spring.

During their freshwater residence, juvenile salmon need abundant food sources to grow and instream cover to protect them from predators. Juvenile fish cover may include undercut banks, overhanging vegetation, logs, root wads, and large substrate (NMFS 2019). Off-channel habitat, side channels, and other low-velocity areas provide refuge during high-flow events. Cool waters offered by springs, seeps, and deep pools offer refuge when stream temperature increases during the summer. Interstices offered by large substrate allow juveniles to seek refuge during the winter.

SR fall-run Chinook salmon have two different juvenile life history strategies; subyearling and yearling, which appear to be a function of temperature regimes of their spawning location. The yearling life history strategy appears to be associated with cooler incubation and initial rearing waters (Connor et al. 2005) and may be an adaptation to contemporary spawning and rearing conditions of this ESU (Williams et al. 2008).

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of SR fall-run Chinook salmon. Spawning and rearing occurs in the Snake River and its tributaries, including the Clearwater, Salmon, Grande Ronde, Imnaha, and Tucannon river basins (Garcia et al. 2010).

The quality of freshwater habitat for SR fall-run Chinook salmon varies substantially throughout the Snake River region. Some spawning and rearing habitats are in relatively good condition, while other areas are minimally to highly degraded (NMFS 2019). Habitat throughout the interior Columbia River Basin tributaries has been degraded by numerous human activities, including 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, timber harvesting, mining, and urbanization [Lee et al. (1997) as cited in NMFS (2019)]. These activities have led to factors that limit the viability of SR fall-run Chinook salmon, including: (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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

To address these issues and to mitigate effects of the operation of the CRS, the Action Agencies in cooperation with private, local, state, tribal, and federal entities have implemented a variety of tributary habitat restoration actions throughout the Snake River region to benefit salmon and steelhead since 2007. Recovery actions in tributary habitats are intended to maintain and improve spawning and rearing habitat for salmon and steelhead and to help maintain cold-water plumes at the mouths of tributaries that provide thermal refugia. NMFS' *ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon and Snake River Steelhead* (NMFS 2017d) include appendices that describe specific tributary habitat actions for SR spring/summer Chinook and steelhead. Tributary habitat actions for spring/summer Chinook salmon and steelhead tend to be implemented higher in the tributaries than where SR fall-run Chinook salmon spawn and rear. However, those tributary habitat actions likely have beneficial cumulative downstream effects on SR fall-run Chinook salmon habitats. NMFS (2017c) discusses mainstem actions that benefit SR fall-run Chinook spawning and rearing habitat in the Snake River. Those actions include Idaho Power Company's fall Chinook salmon spawning program to enhance and maintain suitable spawning and incubation conditions (IPC 1991), as well as cool-water releases from Dworshak Dam to maintain adequate adult and juvenile migration and rearing conditions in the lower Snake River.

In the 2019 BiOp, NMFS (2019) concluded:

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have 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.

Freshwater Migration Corridors

The freshwater migration corridor extends from the spawning and rearing areas in the Snake River subbasins downstream to the Columbia River plume. Migration corridors are considered essential to the conservation of SR fall-run Chinook salmon. Human activities that have affected habitat in subbasin tributary reaches have already been discussed and contribute to the quality and quantity of water downstream and within the migration corridor of the Columbia River. As discussed previously, tributary habitat actions that have already been implemented support SR fall-run Chinook salmon and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, removing barriers to spawning and rearing habitat, and other actions targeted toward addressing limiting factors (NMFS 2019).

The quality of designated critical habitat within the lower Snake River migration corridor is a function of the cumulative impacts of upstream actions, including elevated water temperatures of inflow; impacts from development along the corridor, dam existence and operations; and management within the Columbia River that affects both juvenile and adult SR fall-run Chinook salmon. All these factors combine to affect critical habitat in the mainstem and influence the migration corridor. Habitat within the mainstem lower Snake River has been substantially altered by a number of factors, including basin-

wide water management, the construction and operation of CRS projects, and other human-related activities that have degraded water quality and habitat (NMFS 2019). Within the 2019 BiOp, NMFS describes those factors affecting the behavior and survival of SR fall-run Chinook salmon through the CRS—that information is incorporated here by reference (NMFS 2019). However, the following briefly summarizes that information.

Mainstem dams and dam operations can affect stream temperature, streamflow, gas supersaturation levels, and river habitats. Both the Snake and Columbia Rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Because the temperature regime has been modified by the CRS and elevated inflow temperatures, which results in warmer late summer/fall water temperatures, juvenile and adult salmonids are potentially affected, as well as fish community structure. Warmer stream temperatures may influence predation rates on juvenile fish by predatory fish species. Juvenile fish may also be affected when water is spilled from hydroelectric facilities that increase gas supersaturation and may lead to GBT in fish. All projects create impoundments that affect riverine habitats and can affect travel times, which in turn may increase juvenile fish exposure to both native and non-native predators. Some passage routes through dams (e.g., turbines) may lower juvenile fish survival rates compared to spill bays and surface passage routes that are operated to maximize overall juvenile passage survival and increase it over the baseline condition. The processes, general effects, and mitigation of CRS mainstem dams and dam operations on the functioning of critical habitat are shown in Table 3-5.

In July–August during the beginning of the SR fall-run Chinook salmon adult migration, solar radiation adds heat to the water in the upper layers of reservoirs, which can lead to high stream temperatures and water temperature differentials in the fish ladders in the CRS and other hydro projects. Stream temperatures within fish ladders that exceed 68°F and differentials greater than 1.8°F have been demonstrated to cause delay in fall Chinook salmon and can reduce their successful migration to natal tributaries [Caudill et al. (2013) and McCann (2018) as cited in NMFS (2019)]. During the most extreme summer days, water temperatures within fish ladders in CRS dams can exceed 75.0°F, and fish ladder temperature differentials can exceed 4.5°F [FPC (2019) as cited in NMFS (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 is ongoing to identify if cooler water is available and can be pumped into fish ladder exits.

Table 3-5. The processes and effects of the CRS dams and operations, as well as mitigation efforts to address the effects

Process	Effect	Avoidance, Minimization, or Mitigation Measure
Passage at dams	Reduced juvenile survival due to the existence of the dams (baseline); recent improvements in survival since the 2008 BiOp	Surface passage, increased proportion of spill, flow augmentation, total dissolved gas (TDG) management, bypasses, and fish-friendly turbines
Water storage operations	Altered water quantity and seasonal timing	Flow augmentation; Dworshak Dam cool-water releases
Solar radiation/reduction in mainstem stream velocity	Altered temperature for late summer and fall fish migrants, both in the reaches below the large mainstem storage projects and migration corridors	Dworshak Dam cool-water releases; fish ladder cooling at Lower Granite Dam and Little Goose Dam
Water storage	Reduced sediment transport and turbidity in migration corridors and estuary due to dam existence and to a lesser extent the ongoing operations of the CRS	None at this time
Spill	Increased TDG	System-wide TDG management
Modification (impoundment and water level fluctuation) of mainstem migratory and rearing habitat	Altered food webs, including both predators and prey due to the existence of the dams and to a lesser extent the ongoing operations of the Columbia River System; reduction in shoreline/shallow-water rearing habitat for rearing subyearling fall chinook through presence of impoundments/reservoirs	Avian management, fish bypass outfall placement (away from known predator concentrations), and pikeminnow removal (management), sea lion excluder devices, and pinniped hazing; increase and improve available shallow-water habitat (e.g., placement of dredge material to create habitat and wetland habitat restoration)

Since 2008, when modifications to the physical and operational CRS system were first implemented based on the 2008 BiOp, survival of SR juvenile fall Chinook salmon and adult migrants has improved substantially. As noted earlier, juvenile survival for hatchery-origin subyearling fall Chinook from Lower Granite Dam to McNary Dam has improved from 53.2 percent during 1992–2005 to 70.2 percent during 2008–2017 (Bonneville et al.).

For adult SR fall-run Chinook salmon for the years of 2008 to 2016, the 9-year average survival from Bonneville to Lower Granite Dams averaged 90.8 percent (range of 80.2 to 100.9 percent). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 98.6 percent per project (NMFS 2019).

Estuarine and Nearshore Marine Areas

Critical habitat has been designated for SR fall-run Chinook salmon in the Columbia River estuary (58 FR 68543). NMFS has defined the estuary to include the tidally influenced portion of the Columbia River,

i.e., from Bonneville Dam (RM 146) to the mouth of the Columbia River, including the lower portions of tributaries influenced by tidal action. As such, the lower 26 miles of the Willamette River are also included within the estuary domain.

NMFS (2019) considers a functioning estuary to be essential to the conservation of SR fall-run Chinook salmon. Furthermore, NMFS identified the PBFs for SR fall-run Chinook salmon in estuaries to include areas free of obstruction with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater 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.

NMFS (2019) identified degraded habitat conditions in the estuary as a limiting factor for SR fall-run Chinook salmon. Historically, the Columbia River estuary was more dynamic than it is today. Multiple channels, extensive wetlands, sandbars, and shallow areas, especially in the downstream 50 RM, were influenced by winter and spring floods, low flows in late summer, large woody debris, and high sediment loads (NMFS 2019). As reported by NMFS (2019), the current conditions of the Columbia River estuary have changed as a result of many factors, including dredging to deepen and maintain the Federal Navigation Channel and construction of jetties and pile-dike fields to stabilize and concentrate river flow. Causeways have been constructed across waterways. As noted by NMFS (2019), the mouth of the Columbia River was historically about 4 miles wide but has decreased to about 2 miles wide, and the depth has increased at the Columbia River channel at the bar from less than 20 feet to more than 55 feet.

In particular, NMFS (2019) reported a dramatic decrease in wetland areas associated with the Columbia River estuary. More than 50 percent of the marshes and spruce swamps have been converted to industrial, transportation, recreational, agricultural, or urban areas, with more than 3,000 acres converted since 1948 (NMFS 2019). In the upper reaches of the estuary, many wetlands on the floodplain have been converted to industrial and agricultural lands after levees and dikes were constructed. As reported by NMFS (2019), 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost since the late 1800s. Those wetlands support salmonid food webs both in shallow water and in the mainstem.

Changes in river flow and sediment delivery have also affected critical habitat in the Columbia River estuary. NMFS reports that water storage and release patterns from reservoirs upstream have changed the seasonal pattern and volume of discharge within the Columbia River estuary (NMFS 2019). Discharge has increased in the winter, and peak spring/summer floods have been reduced. NMFS (2019) also reported that model studies indicate that combined human activities in the Columbia River Basin have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40percent (as measured at Vancouver, Washington) and have reduced fine-sediment transport by 50 percent or more. The significance of changes in sediment delivery to SR fall-run Chinook salmon is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean and subyearlings that may spend months in the estuary [Johnson et al. (2018); PNNL/NMFS (2018); and Weitkamp (2018) as cited in NMFS (2019)].

There are no CRS-related barriers to migration in this reach, and there is no evidence that flows are insufficient for migration.

PROPOSED ACTION COMPONENTS SPECIFIC TO SNAKE RIVER FALL-RUN CHINOOK SALMON

The Proposed Action—to continue to operate and maintain the CRS and implement associated mitigation—is fully described in Chapter 2 of this document and associated appendices. Reclamation is also consulting on the Columbia River mainstem effects of six irrigation projects that also have additional and separate ESA review.⁴ The Proposed Action continues multiple operations that benefit SR fall-run Chinook salmon, including flow augmentation, spill, surface passage, intake bypasses, and adult ladder operations. In addition, non-operational conservation measures that have been implemented as part of previous BiOps will continue, including tributary and estuary habitat improvements; fish, avian, and pinniped predator management; and conservation and safety net hatcheries (see Chapter 2). The Action Agencies will continue to coordinate with regional sovereigns and will regularly update plans for water management, fish passage, fish operations, and water quality. The Action Agencies intend to implement these actions commencing in September 2020.

SR fall-run Chinook salmon are exposed to CRS management as follows:

- Streamflow quantity and quality in the Snake River downstream of the Clearwater River confluence and in the Columbia River downstream of the Snake River confluence and out to the ocean;
- Passage through six to eight CRS dams in both the downstream and upstream migrations.

EFFECTS OF THE PROPOSED ACTION ON SNAKE RIVER FALL-RUN CHINOOK SALMON

The overall effects on SR fall-run Chinook salmon of continuing to operate and maintain the CRS involve lessening the negative effects of baseline passage impediments by advancing safe downstream and upstream passage through the CRS mainstem lower Columbia and Snake River dams. Effects of the Proposed Action would include, for example, any potential delayed/latent mortality hypothesized to occur as a result of how operating the dams affects juvenile salmon and steelhead passage at the dams; changes in juvenile fish travel time as a result of upriver CRS operations; and potential exposure to elevated TDG due to spill. Improving juvenile and adult migration survival has been the focus of structural and operational actions under past BiOps, the benefits of which have been documented (Corps et al. 2017a; Bonneville et al. 2018a). These already-completed actions are part of the baseline condition and will continue to provide benefits in the future. The effects of the Proposed Action on the SR fall-run Chinook salmon ESU and its critical habitat are described next by life stage.

Freshwater Spawning, Rearing, and Migration to the CRS

Most of the SR fall-run Chinook ESU use freshwater holding, spawning, rearing, and migration habitats that are not affected by CRS management. However, because some SR fall-run Chinook salmon spawn

⁴ Columbia River mainstem effects of certain Reclamation irrigation projects are included in this CRS consultation because the Columbia River hydrologic modeling incorporates all such impacts. The mainstem Columbia River impacts are included for the Yakima, Umatilla, Deschutes, and Crooked River irrigation projects. SR fall Chinook salmon spawn and rear in these tributaries. The flow impacts of these projects to the mainstem Columbia River are fully integrated in discussions of flow and TDG in the parts of the migratory corridor both used by this ESU and impacted by these projects.

and rear in the mainstem Snake River, individual fish could be exposed to the effects of the Proposed Action for CRS operations (e.g., flood risk management, irrigation, and power generation). Overall, direct effects on individual SR fall-run Chinook salmon from the Proposed Action are minimal.

Some individual fish of this ESU are exposed to habitat improvements through the Tributary Habitat Improvement Program component of the Proposed Action. SR fall-run Chinook salmon will benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that will result from the tributary habitat actions. Adverse effects to individuals from construction of habitat improvement actions are mitigated through compliance with BiOps for Tributary Habitat Improvement Projects (NMFS 2013; USFWS 2013). Habitat improvements are proposed for Snake River tributary watersheds, which make up the one major population group for this ESU. Activities in these freshwater spawning, rearing, and migration habitats include work to improve streamflow protection and enhancement, habitat access, stream complexity, riparian habitat, screening to reduce entrainment, and more.

Juvenile Fall Chinook Salmon Downstream Migration Through the CRS

Juvenile SR fall-run Chinook salmon will be exposed to the effects of CRS operations in the mainstem Snake and Columbia Rivers and during passage through CRS dams. In this migration corridor, juvenile SR fall-run Chinook salmon will also experience the deleterious impacts of a degraded environmental baseline and associated cumulative effects, unless they are transported.

In general, the Proposed Action will continue operations and implement actions to minimize negative effects from both baseline conditions and the Proposed Action. Measures presently being implemented and proposed to continue include flow augmentation; measures to direct juveniles away from turbines, e.g., voluntary spill, surface passage structures, and intake bypass systems; fish-friendly turbines; predator management; and transportation.

Changes in the Proposed Action compared to past operations include a flex spill operation and changed implementation of summer spill. These changes in spill operations will affect this ESU because outmigration is generally during late spring and summer. The intended effect is increased juvenile passage survival for SR fall-run Chinook salmon that are passing through the CRS, as well as decreased potential latent/delayed mortality (if any). The Proposed Action also will likely affect turbidity in the McNary tailrace because of forebay elevation manipulations at John Day Dam intended to disrupt bass and walleye spawning. Drawdown to Minimum Operating Pool measures may also have minor turbidity effects. None of the parameters for juvenile outmigration would change from the environmental baseline; temperature, bird predation, and predation by larger fish would make no difference because of structural or operational measures in the Proposed Action.

The indicators used below to assess the effects of the Proposed Action on juvenile SR fall-run Chinook salmon migration through the CRS are categorized as operational (survival at CRS dams, mainstem Columbia River fish travel time, powerhouse passage proportion, TDG, temperature, turbidity, and predation) and non-operational (predation management, habitat actions, and fish status and trend monitoring). Using these indicators, analyses of effects to SR Fall Chinook during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Survival at CRS Dams

As discussed previously, survival of juvenile SR fall-run Chinook salmon in the Snake and Columbia Rivers is influenced by a suite of factors—passage conditions at mainstem dams, flow conditions, water quality (e.g., temperature, TDG), predators, and whether an individual fish was transported. Survival studies show, with few exceptions, that measures implemented through the previous CRS BiOps and continued into the current Proposed Action have performed as desired, achieving or very nearly achieving the 2008 BiOp juvenile dam passage survival objective of 93 percent for juvenile fall Chinook salmon (NMFS 2017b).

While turbine survival for juvenile migrants is generally lower than spillway survival, survival for surface passage and intake bypass routes can be close to, equal to, or even greater than spillway survival in terms of direct dam survival. We anticipate that increases in spillway passage associated with spring flexible spill may result in increased reach survival. It is important to note that because higher spill levels result in unbalanced energy and degraded tailrace conditions, juvenile survival could be lower as a result of extended tailrace delay and the potential for predation at some projects; however, most predictions expect increased overall survival.

Transportation

Collecting juvenile SR fall Chinook salmon at Lower Granite, Little Goose, and Lower Monumental Dams and transporting them to downstream of Bonneville Dam will continue under the Proposed Action. [DeHart (2012) as cited in NMFS (2017c)] estimated that from 2008–11, an average of 52.8 percent of subyearling fall Chinook salmon were collected and transported. The benefits from transportation appear to be dependent on at what time of year transportation takes place (Smith et al. 2013)

Based on a study by Smith et al. (2013) concluded the following:

Assuming surrogate fish represent naturally produced fish, recent transport operations have likely negatively affected the direct and any delayed survival of juvenile SR fall Chinook salmon migrating during May to mid-June, have had smaller positive or negative effects (depending on the year) between mid-June and mid-to-late July, and have provided a substantial benefit from late July/early August–October as measured by adults returning to Lower Granite Dam.

Average annual reach survival for hatchery-origin subyearling fall Chinook from Lower Granite Dam to McNary Dam has improved from 53.2 percent during 1992–2005 to 70.2 percent during 2008–2017 (Bonneville et al. 2018b). Implementation of the Proposed Action is expected to maintain or improve survival of fall Chinook migrating through the system and reduce potential latent/delayed mortality after the fish pass Bonneville Dam.

Mainstem Fish Travel Time

Under the flex spill plan, spring operations at the eight mainstem CRS dams will include spilling to state water quality limits (anticipated to be 125 percent starting in 2020) for 16 hours per day and to

performance spill operations for 8 hours per day. Patterns and amounts for the performance spill operation were developed using a combination of prescribed spill and performance standard testing guidelines from the 2008 FCRPS BiOp and gas cap spill that use spill up to state water quality standards (with some restrictions for erosion concerns and powerhouse minimums).

No model results on travel time have been produced for juvenile SR fall-run Chinook salmon through the CRS. However, it is reasonable to assume that juvenile fall Chinook migrating downstream during flex spill operations would experience the same migration conditions as the modeled species. Additional flow through the spillways will likely draw a greater proportion of juvenile SR fall-run Chinook salmon migrants from the powerhouse routes (turbines, intake screen bypasses, and sluiceways). Decreasing smolt travel time through the forebay with higher levels of spill through the CRS can provide a survival advantage by reducing exposure time to predators and fostering a more normative synchrony between the physiological process of smolt transformation and the timing of ocean entry. In addition, increasing passage through the spillway will most likely reduce potential latent/delayed mortality. However, degraded tailrace conditions from high levels of spill could result in extended tailrace delay and the potential for predation at some projects. Despite this, the overall survival is predicted to increase.

Powerhouse Passage Proportion

Along with increasing spill in the spring, the Action Agencies propose to replace existing fixed spillway surface passage weirs with adjustable spillway weirs when the current weirs reach the end of their design life at Lower Granite, Lower Monumental, Ice Harbor, McNary, and John Day dams. In addition, they propose to replace the existing, original turbines at McNary, John Day and Ice Harbor Dams with improved new turbines with biologically based designs. These actions to improve structural conditions are anticipated to increase survival of juvenile fish that pass through those routes. In addition, increasing the proportion of water discharged as spill directs a higher fraction of migrants away from powerhouses and toward less hazardous spillways. This will reduce smolt encounters with turbines and intake screen bypass systems, both of which have been hypothesized to contribute to latent/delayed mortality.

Total Dissolved Gas

Spill at CRS dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. This may occur during periods of high flows when involuntary spill is necessary or during set periods of time when water is spilled purposefully to implement the Proposed Action. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, which can result in injury or death. Survival of juvenile salmonids can decrease when TDG levels exceed lethal limits and fish are not able to compensate by swimming into deeper water (Beeman and Maule 2006).

Biological monitoring within the CRS shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 125% of saturation (Antcliffe et al. 2002; Backman et al. 2002; NMFS 2019). When those levels are exceeded, however, there is a corresponding increase in the incidence of signs of GBT symptoms. McGrath et al. (2006) determined that new research supports previous research indicating that short-term exposure to up to 120% TDG does not produce significant effects on juvenile (or adult) salmonids when compensating water depths are available (Beeman and Maule 2006; NMFS 2019). Therefore, it is anticipated that any increase in TDG as a result of implementing the flex spill operation will result in

negligible increases in GBT to outmigrating juvenile SR fall-run Chinook salmon through the CRS, because the Proposed Action is not intended to exceed the 125% “gas cap” during periods of voluntary spill.

Temperature

Temperature changes can cause stress and mortality to SR fall-run Chinook salmon. Temperature influences growth and feeding rates, metabolism, development, migration timing, and the availability of food. In addition, temperature plays a role in predator fish behavior which also affects juvenile salmonid survival. Current temperature conditions are different from historical conditions because of a suite of anthropogenic activities (see the status of the species section).

Cool water releases from Dworshak Dam will help cool water and improve baseline temperature conditions in the mainstem lower Snake River when juvenile fish are emigrating. For adults migrating upstream, operation of pumps and other cooling water devices will help offset warm temperatures in fish ladders. Therefore, it is anticipated that temperature changes attributable to the Proposed Action are likely indistinguishable from current conditions and will result in negligible consequences to outmigrating juvenile SR fall-run Chinook salmon.

Turbidity

The existence of the CRS (and non-federal dams) has decreased sediment transport downstream in the Columbia River Basin because suspended particles tend to settle out when sediment-laden water enters a reservoir, thereby reducing turbidity. Primary mechanisms of sediment delivery to the Columbia River Basin between Grand Coulee and Bonneville Reservoir are landslides and bank erosion that contribute fine-grained sediment that is mostly transported in suspension. Sediment deposits in river reaches now occupied by reservoirs are also subject to shoreline erosion. This is especially true during filling of reservoirs, periods with fluctuating water levels, and reservoir drawdowns. In short, decreased turbidity conditions are part of the environmental baseline because they are primarily associated with the existence of the dams. Lowered turbidity levels may increase the susceptibility of SR fall-run Chinook salmon to avian and piscivorous predators due to increased visibility in the water column.

Sediment supply and transport is affected by dams and flow regulation. Mainstem and tributary dams trap sediment by changing hydraulic conditions in their impoundments and reducing sediment supply in downstream river reaches. Flow regulation and the reduction of peak flows through dam operations further reduce sediment transport capacity. Because sediment transport capacity is much greater at high flows than low flows, reducing the magnitude of high flows can reduce the overall capacity of a reach to move sediment. However, implementing the Proposed Action is unlikely to result in changes in the amount of suspended sediment (and resulting turbidity) in the water column through the CRS when compared to the environmental baseline (refer to the CRSO EIS section 3.3.2.2 and 3.3.3.6 for an expanded discussion of sediment supply). Although, while outmigrating juvenile SR fall-run Chinook salmon will continue to experience less turbid water as a result of past actions, the Proposed Action does include measures to address predation impacts in the vicinity of the dams and in the estuary, as described next.

Predation

A variety of bird and fish predators consume juvenile SR fall-run Chinook salmon on their migration from tributary rearing areas to the ocean (see Section 3.1.2.1). Existing conditions create habitat that is more ideal for both native and non-native predatory fish than pre-CRS conditions. Outmigrating juvenile SR fall-run Chinook salmon encounter predatory fish during passage through reservoirs, dam forebays, and dam tailraces of the CRS.

Implementing the Proposed Action operations will not substantially change environmental baseline conditions for the distribution and abundance of piscivorous fish in the CRS. On one hand, fish in the dam tailraces that may be particularly susceptible to predation could benefit from the flex spill program because increased spill discharge will increase turbulence immediately downstream of the dams, making it more difficult for predators to locate and prey upon juvenile salmonids in these areas. On the other hand, increased spill discharge may disorient outmigrants in spillway tailwaters, leading to greater vulnerability to avian predation.

Non-Operational Conservation Actions

Predation Management

Management efforts to minimize predation by birds and northern pikeminnow will continue with the Proposed Action. Collectively, it is intended that these efforts will continue minimizing predation rates on outmigrating juvenile SR fall-run Chinook salmon passing through the CRS.

The Action Agencies have developed various plans to help minimize predation by birds, a baseline condition influencing the survival and recovery prospects of SR fall-run Chinook. In 2005, the Caspian tern management plan was approved (USFWS 2005), and in 2014 the implementation of the IAPMP began (Corps 2014a). This plan manages avian predation on juvenile salmonids as they migrate to the ocean by reducing bird nesting colonies in inland areas by installing a variety of passive nest dissuasion materials before nesting seasons (Evans et al. 2018). A Double-crested cormorant management plan for East Sand Island in the estuary was completed in 2015—avian dissuasion actions at the dams (e.g., wires, sprinklers, etc.) will continue with the Proposed Action.

Based on PIT-tag recoveries at East Sand Island (near the mouth of the Columbia River), average annual tern and cormorant predation rates for SR fall-run Chinook salmon were about 2.5 and 3.0 percent, respectively, before efforts to manage the size and nesting location of these colonies (Evans et al. 2018). Previous management actions implemented by the Action Agencies to relocate various tern colonies has had some positive effect by reducing the predation rate on SR fall-run Chinook salmon to 0.8 percent (Evans et al. 2018).

The northern pikeminnow, a native fish, is a significant predator of juvenile salmonids in the Columbia River. In 1990, the Action Agencies began the NPMP to reduce predation on juvenile salmonids by northern pikeminnow through targeted removal of northern pikeminnow at mainstem CRS dams. In addition, a Pikeminnow Sport Reward Fishery Program has been instituted that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake Rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to before the start of the

program and estimated a median reduction of 30 percent. Incidental catch of ESA-listed salmon and steelhead as a result of implementing pikeminnow management programs has occurred in the past and is likely to continue at a similar rate in the future. While the numbers are low, some individuals are likely part of the SR fall-run Chinook salmon ESU.

Predator management programs will continue under the Proposed Action. They are anticipated to continue maintaining the benefits achieved to date for reducing consumption of juvenile salmon and steelhead by avian and fish predators. Specifically, continuing the Caspian tern and cormorant management plans and the NPMP will result in negligible changes in predation but will prevent impacts from “backsliding” to levels that existed before the Action Agencies’ implementation of these plans.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E (research, monitoring, and evaluation) programs on SR fall-run Chinook salmon associated with the capturing and handling of fish. RM&E activities occur throughout the Columbia River Basin as part of managing the CRS. In general, the RM&E program is a collaborative, regionally coordinated effort for status and trend monitoring for habitat and fish, action effectiveness monitoring and research, critical uncertainty research, synthesis and evaluation, and data management. Capturing, handling, marking, tagging, and releasing fish is generally stressful and can have sublethal and sometimes lethal effects. Furthermore, some RM&E actions also involve euthanizing fish for research purposes. NMFS (2019) estimated the number of juvenile SR fall-run Chinook salmon that have been handled each year during the implementation of RM&E under the 2008 BiOp and determined that average handling and mortality were not substantial. They concluded:

...slightly more than one percent of the wild juvenile production was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to one percent of these juveniles (in this case, <0.02 percent of the wild production) died after they were released due to effects of handling. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of FCRPS operations, including modifications to facilities, operations, and mitigation actions.

It is reasonable to assume that implementing the Proposed Action will result in the number of individual SR fall-run Chinook salmon handled, injured, and/or killed from RM&E activities continuing in the future at approximately the same level as is currently the case.

Juvenile Fall Chinook Salmon Estuary Migration and Rearing, Including the Plume

Ecosystems in the estuary (defined as the segment from Bonneville Dam to the ocean) and Columbia River plume provide habitat for juvenile SR fall-run Chinook salmon to migrate in, forage, adapt physiologically, and, in some cases, avoid predators. The yearling and subyearling life history patterns of the SR fall-run Chinook salmon ESU exhibit different strategies during migration through the Columbia River estuary. Yearling SR fall-run Chinook salmon migrate rapidly through the estuary, using the navigation channel and other large channels (McMichael et al. 2011) and generally move through the estuary in less than a week, similar to yearling SR spring/summer Chinook salmon. Some subyearlings enter shallow floodplain habitat below Bonneville Dam (Fresh et al. 2005). SR fall-run Chinook salmon

can be present in the estuary as juveniles in winter, as fry from March to May, and as fingerlings throughout the summer and fall (Roegner et al. 2012; Teel et al. 2014; Weitkamp et al. 2014).

The existence and operations of the CRS have led to long-standing changes in the hydrograph, TDG, and amount of sediment and large wood deposited in the estuary. However, any direct impacts on these parameters due to the Proposed Action of continuing CRS management are expected to be minor.

There is an apparent relationship between plume characteristics at time of ocean entry and smolt-to-adult (return) ratio (SARs) for Chinook salmon. Jacobson et al. (2012) found that for spring-run Chinook salmon, which are primarily yearlings, early marine growth leads to variation in body length, with survival being higher in years when the coastal waters are cool and productive. For subyearling Chinook, the pattern reverses when ocean conditions are cool and productive, which could reduce survival.

Avian predation continues to be a serious environmental baseline issue in the estuary. Previous management actions, like modifying nesting habitat to relocate colonies away from known high-predation areas, has reduced the impact of avian predation. Continuing avian predator management in the estuary under the Proposed Action will benefit this ESU by reducing the number of fish eaten by birds [e.g., see figures 50 and 52; Corps et al. (2017a), Section 1]. The continued estuary habitat actions will likely benefit the subyearling portion of the juveniles more than the yearlings because of the length of time spent in the estuary (longer for subyearlings).

The indicators used below to assess the effects of the Proposed Action on juvenile SR fall-run Chinook salmon migration through the estuary and plume are categorized as operational (survival, fish travel time, TDG, temperature, turbidity, and predation) and non-operational (predation management, habitat actions, and fish status and trend monitoring). Using these indicators, analyses of effects to SR fall-run Chinook salmon during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Survival

Foraging and growth in the estuary improves fish condition and likely increases subsequent survival during early ocean residence. Monitoring and research data suggest that fish size and time of ocean entry, which are in part due to conditions in the estuary, can affect salmonid growth and survival in the ocean (Chittaro et al. 2018; Johnson et al. 2018). Habitat enhancements that increase access to rearing areas improve habitat capacity (e.g., prey productivity) and increase prey export to the mainstem estuary, likely leading to increased growth and improved condition of migrating juvenile SR fall-run Chinook salmon in the estuary.

Fish Travel Time

Changes in CRS water management in the Proposed Action are not expected to alter fish travel time through the estuary. Therefore, under the Proposed Action, travel time in the estuary of juvenile SR fall-run Chinook salmon is not likely to change from the baseline condition.

Total Dissolved Gas

Elevated TDG levels that occur during periods of increased spill downstream are attenuated by approximately RM 110, downstream from Bonneville Dam (NMFS 2019). Juvenile SR fall-run Chinook salmon exposed to increased TDG levels (120% to 125%) have the potential to experience slight increases of GBT resulting from the Proposed Action as compared to the baseline condition.

Temperature

Water temperature changes caused by the Proposed Action are not expected in the estuary and plume due to the distance (100s of miles) from CRS storage reservoir releases for purposes of influencing temperature.

Turbidity

Implementing the Proposed Action is not likely to affect turbidity levels in the estuary and plume.

Predation Rates

The Proposed Action is not anticipated to have any effect on the rate of juvenile salmonid predation in the Columbia River estuary and plume.

Non-Operational

Predation Monitoring

The Proposed Action will continue to implement the various predator management programs that are currently being implemented in the estuary and mainstem Columbia River. Some ESA-listed fish are captured as part of implementing the Pikeminnow Sport Reward Fishery and dam angling program. The number of individual fall Chinook impacted is likely to continue at a similar rate in the future. While the numbers are low across the entire program, some individuals below Bonneville Dam and in the estuary may be captured, injured, or killed, but it is anticipated that the numbers will remain below what NMFS considers needing corrective action.

Estuary Habitat Actions

As part of the Proposed Action, the Action Agencies will continue implementing the CEERP to improve estuary floodplain habitats, including tidally influenced portions of tributaries, used by outmigrating salmon and steelhead. The planned improvements in habitat functions are expected to provide long-term benefits to native species that use these habitats through improved ecological functions and processes. Appropriate ESA consultation is typically undertaken prior to implementation of these projects at a site-specific scale. These ESA consultations are complete with implementing terms and conditions that the Action Agencies comply with. Project effectiveness is expected to increase over time as the restored habitats mature and new, more effective restoration projects are implemented because program sponsors will be taking into account lessons learned from previous projects within CEERP's adaptive management framework (Diefenderfer et al. 2016).

Fish Status and Trend Monitoring

The RM&E component of CEERP includes actions to monitor status and trends of habitat and fish, perform action effectiveness monitoring and research, and conduct critical uncertainties research. CEERP is implemented using an adaptive management process to capture learning from RM&E and adjust program strategies and actions accordingly (Johnson et al. 2018). RM&E will continue under the Proposed Action. Capture and handling of juvenile salmon and steelhead, some of which are likely SR fall-run Chinook salmon, may result in stress, injury, harm, and in extreme cases, death as part of RM&E in the estuary and plume.

Ocean Rearing

CRS management has no *direct* influence on survival of SR fall-run Chinook salmon in the Pacific Ocean. There are, however, a small number of individual salmon and steelhead that could experience deleterious direct effects from capture and handling from a Bonneville-funded study of juvenile salmonid ecology in the plume and nearshore ocean. *Indirect* effects on survival of SR fall Chinook salmon from CRS management include any latent/delayed mortality manifested in the ocean and the positive influence CRS management can have on juvenile migration and growth in the estuary, which is related to improved survival during early ocean entry.

The Proposed Action will have no effect on the ocean habitats used by SR fall-run Chinook salmon for growth and maturing because there are no CRS operations that affect this area (the Columbia River plume was addressed above).

Adult Fall Chinook Salmon Migration to Bonneville Dam

Data on migration rates from the ocean to Bonneville Dam do not exist for SR fall-run Chinook salmon. However, NMFS (2014a) reported that adult SR spring/summer Chinook salmon took, on average, 18.1 days in 2011 and 15.4 days in 2012 to migrate up that reach of the river. It is reasonable to assume adult SR fall-run Chinook salmon spend about 2–3 weeks migrating upstream in the estuary before reaching Bonneville Dam.

The Proposed Action is unlikely to cause adult migration barriers for SR fall-run Chinook in the estuary where river discharge should be sufficient for adult migration. As noted earlier, pinniped predation negatively affects adult migration within this reach, although it is not caused by CRS operations. The Action Agencies' proposed pinniped management actions at Bonneville Dam are expected to reduce this environmental baseline impact to some degree. Thus, overall, the Proposed Action is likely to have negligible effects on adult SR fall-run Chinook salmon in the Columbia River from the ocean to Bonneville Dam.

Further analysis of effects to adult SR fall-run Chinook salmon returning to the Columbia River and migrating up to Bonneville Dam as a result of implementing the Proposed Action is described next. The analysis is organized by operational and non-operational components.

Operational

Survival

The Proposed Action is not expected to negatively affect the migration corridor, and hence survival, for adult SR fall-run Chinook salmon in the estuary (Bonneville Dam to the ocean).

Travel Time

The Proposed Action will result in negligible reductions in flow and water particle velocity when adult SR fall-run Chinook salmon will be entering and migrating up the estuary. Therefore, the Proposed Action is not expected to result in a measurable increase or decrease in the migration rate of adult SR fall-run Chinook salmon up to Bonneville Dam.

Total Dissolved Gas

As a result of the flex spill operation during spring, there is a slight potential that early migrating adult SR fall-run Chinook salmon will be exposed to slightly elevated TDG levels. Most adult SR fall-run Chinook salmon, though, enter the Columbia River from the ocean in July and August after the flex spill program has concluded and, as such, will not be exposed to potentially elevated levels of TDG. Therefore, based on the attenuating effect on TDG of distance downstream of the CRS, the influence of tributary streamflow, and the timing of adult SR fall-run Chinook salmon migration to Bonneville Dam, the Proposed Action is not expected to adversely affect adult SR fall-run Chinook salmon in the estuary during migration to Bonneville Dam.

Temperature

Poor water quality, which includes increased water temperature, can lead to stress in adult SR fall-run Chinook salmon. This in turn can lead to reductions in biological reserves, altered physiological processes, increased disease susceptibility, and decreased performance (e.g., growth) of individual fish. Furthermore, elevated water temperatures can affect salmonid distribution, behavior, migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult UCR steelhead (NMFS 2019).

Effects of the Proposed Action are not expected to result in elevated water temperatures downstream from Bonneville Dam and, therefore, are not likely to negatively impact adult SR fall-run Chinook salmon within this reach.

Turbidity

Existence of the CRS has decreased sediment loads transported downstream by the Columbia River. In fact, it is estimated that the total sediment discharge into the estuary and the Columbia River plume is approximately one-third of pre-hydrosystem levels (NMFS 2019).

Effects of the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam and, therefore, are not likely to negatively impact adult SR fall-run Chinook salmon within this reach.

Non-Operational

Predation Management

For adult SR fall-run Chinook salmon migrating upstream in the estuary to Bonneville Dam, the primary factor affecting survival is pinniped predation. The existence of Bonneville Dam, which is part of the environmental baseline, likely causes pinnipeds to congregate downstream from that project. Estimates of pinniped predation downstream of Bonneville Dam are not available for adult SR fall-run Chinook salmon; however, salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). In a study assessing pinniped predation on adult salmonids and other species, Tidwell et al. (2019), estimated a consumption rate of 0.7 percent for Chinook salmon during the fall period, when SR fall-run Chinook salmon are migrating.

To reduce the baseline condition of pinniped predation on adult salmonids, management measures such as hazing, removal, and structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and floating orifice gates) will continue under the Proposed Action. No components of the Proposed Action are expected to change from current conditions associated with pinniped predation and therefore will not affect adult SR fall-run Chinook salmon.

It is anticipated that the Action Agencies will continue to implement the NPMP as well as the Sport Reward Fishery in the lower Columbia River estuary, and that fall Chinook salmon, including some adult SR fall-run Chinook salmon, will be handled and/or killed during those activities. However, these activities are expected to maintain the 30 percent reduction in predation rates achieved under the 2008 Reasonable and Prudent Alternative (RPA;(NMFS 2019)).

Adult Fall Chinook Salmon Migration Through CRS Dams

Most SR fall-run Chinook salmon populations migrate upstream through all eight lower Columbia and Snake River CRS projects on their way to spawning grounds. Exceptions are the Tucannon River population and the fish that spawn in the mainstem Snake River. An analysis of effects to adult SR fall-run Chinook salmon migrating upstream through the CRS as a result of implementing the Proposed Action follows. The analysis is organized by operational and non-operational components.

Operational

As discussed previously, the Proposed Action includes flex spill for spring juvenile fish passage operations from April 3 through June 20 at the lower Snake River projects and April 10 through June 15 at the lower Columbia River projects.

The Proposed Action also includes modifying the Bonneville ladder serpentine weir to reduce delay within the fishway (this structural change is included under operational effects for convenience) and providing flexibility to decrease pool elevation in John Day Reservoir by 0.5 feet to increase water particle velocity and reduce fish travel time. Collectively, these measures along with the flex spill Program have the potential to impact SR fall-run Chinook salmon, as described next.

Survival

Data on conversion and minimum survival rates were presented in the section above on factors affecting the status of SR fall-run Chinook salmon.

Fallback

Adult SR fall-run Chinook salmon can fallback at dams while migrating upstream to their natal streams. Fallback through a dam after exiting into the forebay from a fish ladder is often associated with higher spill levels at the project. The mean annual fallback rates at the lower Columbia River dams has been estimated to be 11.6 percent over 4 years of study from 1998 to 2002 for the CRS dams on the lower Columbia and Snake Rivers (Keefer et al. 2004).

The Proposed Action, specifically the flex spill program, will have the potential to increase the rate of fallback at CRS dams. With increased spill, it is likely that more of the fish that fallback at a given project will do so through the spillway or some surface-oriented passage route. However, spill at lower Columbia River dams will terminate on June 15 and on June 20 at Snake River dams—most adult SR fall-run Chinook will not be present prior to these dates. However, if fish do fallback during the flex spill program, survival of that fallback event is expected to be relatively high. Results from Keefer et al. (2016) demonstrate the high survival of fish passing through the various routes available to adults. At Bonneville Dam, direct survival tests using rainbow trout as a surrogate revealed that for fish passing downstream of the dam via the B1 sluiceway and the B2 corner collector, survival was greater than 98 percent (after 48 hours). At McNary Dam, direct survival was estimated to be approximately 98 percent through the temporary spill weir (TSW). Conversely, direct survival through the McNary turbines was estimated to be approximately 91 percent (Keefer et al. 2016). For later migrating fish, i.e., those that ascend the CRS after termination of the flex spill program, rate of fallback is not expected to change.

In sum, the Proposed Action has potential to negatively affect SR fall-run Chinook salmon by increasing fallback, but because of upstream migration timing of SR fall Chinook salmon, the potential is considered very low.

Water releases from Dworshak Dam

As discussed above, releasing cooler water from Dworshak Dam in the summer cools the mainstem Snake River, which decreases potential negative effects of increased water temperature on adult migration. Under the Proposed Action, reservoir operations at Dworshak will continue to cool temperatures in the lower Clearwater River and lower Snake River reservoirs during summer to improve environmental conditions for adult migrants.

Total Dissolved Gas

Adult SR fall-run Chinook salmon migrate upstream past Bonneville Dam from August through the end of September, with peak migration in August. Since the flex spill program will occur April 3 through June 20 at the lower Snake River projects and April 10 through June 15 at the lower Columbia River projects—most adult SR fall-run Chinook salmon will not be exposed to elevated levels of TDG.

As described in the previous section, GBT is not typically observed when TDG levels do not exceed 120 percent and generally do not become more pronounced until TDG levels exceed 125 percent saturation

(NMFS 2019). Based on the limited observations of GBT at expected TDG levels associated with the Proposed Action and given the migrational timing of adult SR fall-run Chinook salmon within the CRS, the Proposed Action is not expected to result in an elevated risk of GBT to SR fall-run Chinook salmon.

Temperature

As described previously, poor water quality, including increased water temperature, can have adverse effects adult SR fall-run Chinook salmon. In the lower Snake River, there will be positive effects (decrease) to temperature from cool water releases from Dworshak Dam and cooling in the fish ladders at Lower Granite and Little Goose dams. Because the Proposed Action will not cause elevated water temperatures within the CRS, the Proposed Action is not expected to result in temperature related effects to adult SR fall-run Chinook salmon within this reach.

Turbidity

Hydropower development in the Pacific Northwest has altered the extent of sediment transport downstream through the Columbia River, including within the CRS. While other anthropogenic activities such as agriculture, irrigation, mining, logging, and road building have increased sediment delivery to the mainstem Columbia River, both federal and non-federal dams act as sediment traps, decreasing sediment loads discharging downstream. These activities and baseline conditions are expected to continue at current rates.

Because actions associated with the Proposed Action are not expected to result in changes in baseline sediment load, the Proposed Action is not expected to affect adult SR fall-run Chinook salmon within the CRS.

Non-Operational

Predation Management

Predation on adult SR fall-run Chinook salmon within the CRS is rare, with pinnipeds being the primary predator. Pinniped predation commonly occurs in the Bonneville Dam tailrace and in the estuary downstream to the Pacific Ocean. While pinniped observations upstream from Bonneville Dam are not common; no pinnipeds have been observed above The Dalles Dam. The Proposed Action is not expected to change pinniped predation on adult SR fall-run Chinook salmon.

In addition, predator fish management programs, like the NPMP, could potentially affect SR fall-run Chinook salmon by the accidental hooking of adults at the dams and during fishing for northern pikeminnow elsewhere in the CRS. There is also the potential for bycatch while the number of pikeminnow are being indexed through electroshocking. However, the incidental catch of adult SR fall-run Chinook salmon during these activities has remained below take limits for the NPMP (Williams et al. 2019).

Adult Fall Chinook Salmon Migration Upstream of the CRS to Spawning Areas

After migrating upstream through the CRS, the adult SR fall-run Chinook salmon that spawn in tributaries migrate toward their natal streams. Once they enter those tributaries, they are no longer

exposed to the operation and related effects of the CRS. Overall, the Proposed Action is not expected to adversely affect SR fall-run Chinook salmon as they migrate upstream of the mainstem CRS dams to their natal streams.

Operational

For the most part, exposures of SR fall-run Chinook salmon to the majority of CRS-related water quality and quantity aspects of the Proposed Action are reduced dramatically after passing the lower Snake River CRS dams. Once they enter their natal tributaries, adult SR fall-run Chinook salmon are no longer exposed to the operation and related effects of the CRS.

Non-Operational

Within SR fall-run Chinook salmon tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this ESU. The following provides a brief description of the effects of those actions.

Hatchery Programs

The hatchery program described above will be implemented into the future without alteration under the Proposed Action. As such, no change in SR fall-run Chinook salmon is anticipated due to hatchery operations.

Tributary Habitat Actions

Nearly all of the historical habitat for SR fall-run Chinook salmon has been extensively modified through anthropogenic actions. As described previously, many factors limit the viability of this ESU. In response, many habitat measures have been implemented specifically to benefit SR fall-run Chinook salmon by federal, state, local, and private entities, including the Action Agencies.

Based on the best available science, NMFS has concluded that these actions have improved and will continue to improve habitat for SR fall-run Chinook salmon. Furthermore, fish population abundance, productivity, spatial structure, and diversity should respond positively to improvements to the baseline conditions (NMFS 2019).

Fish Status and Trend Monitoring

The Action Agencies' RM&E program is expected to continue at its current or a lesser level of effort. RM&E effects on SR fall-run Chinook salmon are associated primarily with the capture, handling, marking, and tagging of fish. The level of injury and mortality to adult SR fall-run Chinook salmon from RM&E is expected to be maintained at current or slightly decreased levels.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Effects of the Proposed Action on critical habitat for SR fall-run Chinook salmon were assessed based on the action elements likely to affect PBFs essential for the conservation of the ESU. Effects cover critical

habitat for tributary spawning and rearing, the freshwater migration corridor through the mainstem CRS dams, and the estuary and nearshore ocean.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of SR fall-run Chinook salmon. These areas occur within mainstem sections of the Snake River and in tributary watersheds upstream of the CRS. The Tributary Habitat Improvement Program is intended to improve habitat function for SR fall-run Chinook salmon. At the time of submittal of the Proposed Action, there will be some uncertainty about the actual locations, extent, and types of habitat actions that will be implemented as part of the Proposed Action. Anticipated effects of the construction through the habitat program are expected to be mitigated through adherence with the recommendations in the BiOp on the Columbia River Habitat Improvement Program (NMFS 2013) and the lessons learned over the years of successful implementation of this Program.

Freshwater Migration Corridors

Freshwater migration corridors are used by returning adult SR fall-run Chinook salmon migrating upstream through the CRS and by juveniles migrating downstream. The baseline existence of the CRS dams will continue to affect the function of critical habitat within the mainstem Columbia and Snake rivers. The Proposed Action includes ongoing actions to maintain or improve the freshwater migratory PBFs through operation and maintenance of passage improvements through the system and implementation of the predator management programs intended to reduce the consumption of juvenile and adult salmon within the CRS and estuary. These programs are intended to improve survival through the CRS and will continue to reduce the risk of predation on SR fall-run Chinook salmon.

The Proposed Action also includes both structural and operational modifications to the CRS that may affect the PBFs related to water quality and passage conditions that SR fall-run Chinook salmon must migrate through to complete their life cycle. However, the overall effects to these PBFs from implementing the Proposed Action are slightly positive with respect to passage conditions and risk of predation and slightly negative relative to elevated TDG. The existence of the CRS is expected to continue to cause effects to stream temperature, sediment, and turbidity PBFs are anticipated with the CRS but are likely to remain unchanged as a result of the Proposed Action. Passage conditions at each of the projects are anticipated to improve for juvenile fall Chinook salmon as the flex spill program will provide more advantageous passage routes through spill bays at each of the projects. Increasing the proportion of water discharged through the spill bays at each of the dams will reduce forebay residence time by providing a more pronounced surface-oriented flow path for juvenile fall Chinook salmon, which is hypothesized to reduce latent/delayed mortality.

Estuary and Nearshore Ocean Areas

Estuary and nearshore ocean areas have been designated as essential for the conservation of SR fall-run Chinook salmon. Ongoing implementation of CEERP and predator removal and harassment programs is anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of CEERP is likely to increase the baseline capacity and quality of habitat in

the estuary while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal and harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to improve the safe passage feature of critical habitat.

The Proposed Action includes operational modifications to the CRS that may affect the water quality habitat features downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions with a slight but potential increase in TDG associated with the flex spill program. Elevated TDG levels (125%) may occur in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). Continued effects to stream temperature, sediment, and turbidity PBFs are anticipated downstream from the CRS but are likely to remain unchanged from the current condition as a result of the Proposed Action. Current passage habitat features will be unaffected for juvenile and adult SR fall-run Chinook salmon as they migrate through the Columbia River estuary and into nearshore ocean.

SUMMARY OF THE ENVIRONMENTAL BASELINE, CUMULATIVE EFFECTS, AND ACTION EFFECTS

This section summarizes the effects of the Proposed Action on SR fall-run Chinook salmon in the context of the environmental baseline condition and cumulative effects. Cumulative effects are effects of future state or private activities that are reasonably certain to occur within the action area (50 CFR § 402.02). To the extent ongoing activities (whether they are federal, state, or private) have occurred in the past and are currently occurring, the past and present effects of those activities are included in the baseline condition, while the ongoing effects of operations that will be continued in the Proposed Action will be included in effects of the action. To the extent similar state or private activities are reasonably certain to occur in the future, their future effects are included in the cumulative effects analysis.

Most of the action, baseline, and cumulative effects identified in the analysis above are consistent with effects previously described for operation of the CRS in past consultations. In general, the Proposed Action as a whole is not likely to limit species survival or critical habitat function. It carries forward a suite of beneficial actions that improve baseline conditions and offset negative effects attributable to the regulation of flows, including flow augmentation, fish passage operations, predation management, and habitat improvement. Though the Proposed Action does not cause substantial changes to current species conditions, there may be some modest site-specific effects from the continued operation of the CRS. It is also possible that increased spill levels, and associated adverse effects, will be offset by an increase in adult returns due to less powerhouse encounters as hypothesized by the CSS. returns modeling.

The summary below follows the general structure of the effects analysis above, with operational and non-operational components.

Operational

Survival

Baseline: Survival of juvenile SR fall-run Chinook salmon through the CRS is affected by the number of CRS dam and reservoir projects they pass, predators, travel time, and water quality. These conditions are the result of multiple factors, including the existence of the CRS dams and CRS operations. Survival has improved for juvenile SR fall-run Chinook salmon migrating through the CRS to the ocean as a result of past changes in operations and improvements to baseline conditions. Juvenile Chinook salmon survival has also improved in the estuary and tributaries due to habitat improvements implemented by the Action Agencies. For adult SR fall-run Chinook salmon, survival has been and is currently affected in the estuary up to Bonneville Dam by pinniped predators.

Cumulative effects, including the effects of climate change and variable ocean conditions have the potential to affect survival of SR fall-run Chinook salmon. Land-use activities (primarily non-federal) have the potential to affect juvenile survival by decreasing tributary and estuary habitat or degrading abiotic factors, such as stream temperatures from urban, rural, and agricultural development and runoff. Further degradation of tributary habitat could also affect adult Snake river fall-run Chinook salmon survival by reducing holding and spawning areas or causing development of passage barriers. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies implement fisheries that can have a direct effect on the number of returning fall Chinook to the Snake River (and in some cases, within the tributaries themselves).

It is anticipated that survival gains resulting from previous habitat improvement actions that improved baseline conditions will continue and possibly increase as a result of the continuing benefits from tributary and estuary habitat actions. It is also anticipated that structural improvements to juvenile and adult passage conditions at the CRS dams will be maintained. For downstream migrating juveniles, it is anticipated that not only will survival through the CRS improve, but ocean survival may increase as a result of fish entering the ocean with fewer powerhouse encounters during their downstream migration, should the latent mortality hypothesis prove valid. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications to actions.

Fish Travel Time

The existence operation of the CRS dams slow juvenile travel time, potentially increasing exposure to predators as they migrate through the CRS. Travel time within the tributaries and estuary are not affected by the existence or operation of the CRS. While travel time of juveniles within the CRS varies from year to year, it is predicted that the Proposed Action operations, as well as structural changes made in past actions that have continuing benefits from more fish going through non-turbine routes, will result in decreased travel time and improved survival. Adult travel time is not considered an issue., but the Action Agencies have proposed to continue monitoring this and, where beneficial and feasible, develop and implement operational or structural solutions to address temperatures in all fish ladders.

Future state and private actions are not expected to affect travel time of juveniles or adults through the CRS during any life stage. However, it is anticipated that the projected increased air temperature due to

climate change will likely continue to increase overall temperatures in the Columbia River, and therefore have the potential to further affect the timing of adult SR fall-run Chinook salmon upstream migration, and possibly juvenile migration timing.

The Proposed Action is anticipated to reduce forebay residence time for juvenile SR fall-run Chinook salmon migrating past the CRS during the flex spill plan implementation. Continued monitoring of adult SR fall-run Chinook salmon migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions designed to improve migrational conditions.

Powerhouse Passage Proportion

Past and current physical and operational modifications of the CRS have increased the percentage of juvenile fish passing through non-turbine routes. Decreasing powerhouse passage improves survival of juveniles during their downstream migration and provides a safer route of passage for adult migrants that overshoot their natal stream.

The effects from state and private actions are not anticipated to affect juvenile SR fall-run Chinook salmon powerhouse passage.

The Proposed Action will continue implementing past improvements and actions that have resulted in increased non-turbine passage at the CRS projects. Additional powerhouse surface passage routes and upgraded adjustable spillway weirs at Lower Granite, Lower Monumental, Ice Harbor, McNary, and John Day Dams will improve juvenile passage and offer a greater range of surface-oriented passage operations throughout the migration season.

Total Dissolved Gas

TDG has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high levels that resulted in GBT in juveniles and adults as they migrated through the CRS. Elevated TDG levels are not observed within tributaries or the estuary (where the effects of CRS operations on TDG are attenuated by distance and tributary inflow). The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

The only state or private actions that will affect TDG levels in the mainstem Columbia River are potential modifications to state water quality criteria. Continued monitoring of juveniles and adults for signs of GBT will inform managers on the effects of this action.

It is anticipated that implementing the flex spill program will elevate TDG levels and may slightly increase the incidence of GBT in juvenile and adult fish.

Temperature

Water temperatures have been modified as a result of a range of anthropogenic activities, including construction and operation of federal and non-federal dams throughout the Columbia River Basin. Increases in temperature can have a range of effects on both juvenile and adult SR fall-run Chinook salmon.

Ongoing non-federal land management activities that affect temperature, such as agriculture, urban and rural development, and forestry, are not expected to change substantially during the period of this consultation. These activities, coupled with continued population growth in the region, will likely result in further degradations to the environment that influences water temperatures. However, small improvements may be realized from tributary actions that restore and preserve habitat, like riparian plantings.

Implementation of the habitat enhancement actions component of the Proposed Action will improve tributary temperatures but will continue to have minimal effect on mainstem temperatures.

Turbidity

Currently, sediment loads in tributaries have been affected by historic land-use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and rearing habitat. In the mainstem Columbia and Snake Rivers, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk. These baseline conditions will persist during the period of the Proposed Action.

In the tributaries of the Snake River, non-Federal actions such as urban, rural, and agricultural development are likely to continue to affect turbidity. However, improvements in tributary habitat included in the Proposed Action are expected to reduce sediment inputs, resulting in modest, site specific improvements that will mitigate continued non-CRS activities that degrade habitat. In the CRS, the current condition is not anticipated to change, and no non-Federal activities are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment delivery levels from the tributaries. On the mainstem Columbia River, it is not anticipated that the Proposed Action will change the current condition.

Dam Passage (Adults)

Currently, SR fall-run Chinook salmon migrate upstream through CRS projects on their way to natal spawning areas and experience a variety of factors affecting them, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish. Current adult passage conditions should improve with modifications at Bonneville Dam and Lower Granite Dam fishways, which should help reduce delay. Continued operation of the pumping systems to provide cool water in adult fish ladders, where installed, should also improve adult passage conditions within the CRS and the Action Agencies have committed to monitoring and evaluating the need for additional operational or structural measures to address elevated temperatures in the fish ladders. These components of the action are aimed at improving baseline passage impediments resulting from the existence of the dams. SR fall-run Chinook salmon survive their migration through the CRS at high levels, and those survival rates are expected to continue with implementation of the Proposed Action. In addition, adult Chinook salmon that fall back at CRS projects should benefit from the flex spill program because surface-oriented passage routes through the spillways should guide more adults away from powerhouse passage routes, thereby reducing injury from powerhouse passage.

Non-Federal actions that have the potential to directly affect SR fall-run Chinook adult CRS dam passage are unlikely. However, the continued degradation of tributary habitat along with the projected increase in air temperature due to climate change will likely result in warming surface water temperatures— this could indirectly influence migratory behavior in ways that slow or delay upstream migration and reduce survival and reproduction.

The Proposed Action will continue to monitor adult migration through the CRS and use that information to propose specific actions that will increase adult survival.

Non-Operational

Predation Management

Currently, both juvenile and adult SR fall-run Chinook salmon encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinniped predators prey on adults as they enter the Columbia River from the ocean to the tailrace of Bonneville Dam. A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS, mostly in the tailraces of dams. This predation accounts for a portion of juvenile mortality during migration through the CRS.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS operations have no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

The Proposed Action will continue to implement the predator management programs, which should ensure that predation does not worsen, and may reduce overall predation rates over time. Some minor impacts to SR fall-run Chinook will occur as a result of implementing the northern pikeminnow predation program.

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs, including four fall Chinook hatchery programs in the Snake River Basin. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to operation of federal and non-federal dams, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin Chinook salmon and their habitat depends on the design of hatchery programs (which operate under existing and the effects of which are in the environmental baseline consultations), the condition of the habitat, and the status of the species, among other factors.

The majority of hatchery programs are operated by the state in which they occur or by tribes. It is anticipated that most of the current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue. Current hatchery programs will continue to be studied, and management agencies will make recommendations to reduce potential effects if they occur.

Habitat Actions

Habitat conditions in the tributaries, mainstem Columbia and Snake Rivers, and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in the mainstems, tributaries, and in the estuary.

Non-federal actions that have the potential to affect SR fall-run Chinook salmon include continued degradation of habitat that increases temperatures and a projected increase in air temperature due to climate change that will likely warm surface water temperatures.

The Proposed Action will continue to improve the degraded baseline condition of habitat in the tributaries and estuary and thereby improve long-term survival of SR fall-run Chinook.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on SR fall-run Chinook salmon. These are associated with the capturing and handling of fish. Research, monitoring, and evaluation activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no known non-federal RM&E actions anticipated that would affect SR fall-run Chinook.

The Proposed Action will continue to implement the RM&E programs that are currently occurring, with the potential to modify these programs in the future as the results of the monitoring programs are evaluated. While some individuals are harmed, even killed, as a result of RM&E activities, the actual numbers are relatively small, and the information gained outweighs these minor losses.

Summary

In Table 3-6, the Proposed Action is compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action.

Most of the actions are anticipated to either have no effect, or a positive effect compared to the baseline condition (Table 3-6). This is partly because the Proposed Action continues numerous beneficial actions developed over the preceding decade, including habitat improvement, flow augmentation, and fish passage operations. Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-6. Summary comparison of the Proposed Action to current conditions for SR fall-run Chinook salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile Life stage affected	Adult Life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Chinook Salmon Downstream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival.
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes				Not applicable.

Life History Phase	Factor	Juvenile Life stage affected	Adult Life stage affected	Change from current condition	Comment
	fallback and overshoot)				
	Predation rates	x	x	+	Continuation of predator management programs should decrease predation.
	Hatcheries	x	x	=	
	Predation monitoring	x	x	=	
	Fish status and trend monitoring	x	x	=	
Juvenile Chinook Salmon Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable

Life History Phase	Factor	Juvenile Life stage affected	Adult Life stage affected	Change from current condition	Comment
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Chinook Salmon Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
Fish status and trend monitoring		x	=		
Adult Chinook Salmon Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable

Life History Phase	Factor	Juvenile Life stage affected	Adult Life stage affected	Change from current condition	Comment
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	DWK releases and pumping in LGS and LGR
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce overshoot.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
	Survival		x	=	
Adult Chinook Salmon Migration Upstream of the CRS to the Spawning Areas	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring		x	=	

3.1.2.2 Snake River Sockeye ESU

This section examines the status of the SR sockeye, the status of SR sockeye critical habitat, and the effects of the Proposed Action on SR sockeye.

STATUS OF THE SNAKE RIVER BASIN SOCKEYE ESU

The SR sockeye ESU was first listed under the ESA on November 20, 1991, at which time it was classified as endangered (56 FR 58619). That status was reaffirmed on June 28, 2005 (70 FR 37160), and critical habitat for the ESU was designated on December 28, 1993 (58 FR 68543 ; NMFS 2016a)

This ESU includes all residual and anadromous sockeye salmon within the Snake River Basin, as well as artificially propagated sockeye salmon from the Redfish Lake captive broodstock program. Historically, sockeye salmon were native and abundant within numerous lake systems of the Snake River Basin and included populations in the Wallowa River Basin (one), the Payette River Basin (two), the South Fork of the Salmon River (one), and the upper Salmon River (five). Historical populations in the upper Salmon River drainage included Alturas, Pettit, Redfish, Stanley, and Yellow Belly lakes (Figure 3-15). Of the historical populations, only the beach-spawning Redfish Lake population is extant. It is supported by a captive broodstock program initiated in 1993. This single population, the last remaining SR sockeye population, is part of the Sawtooth Valley MPG, as defined by the Interior Columbia Technical Recovery Team. Currently, reintroduction efforts derived from the Redfish Lake captive broodstock program (NMFS 2016a) are ongoing in Pettit Lake (started in 1995) and Alturas Lake (started in 1997).

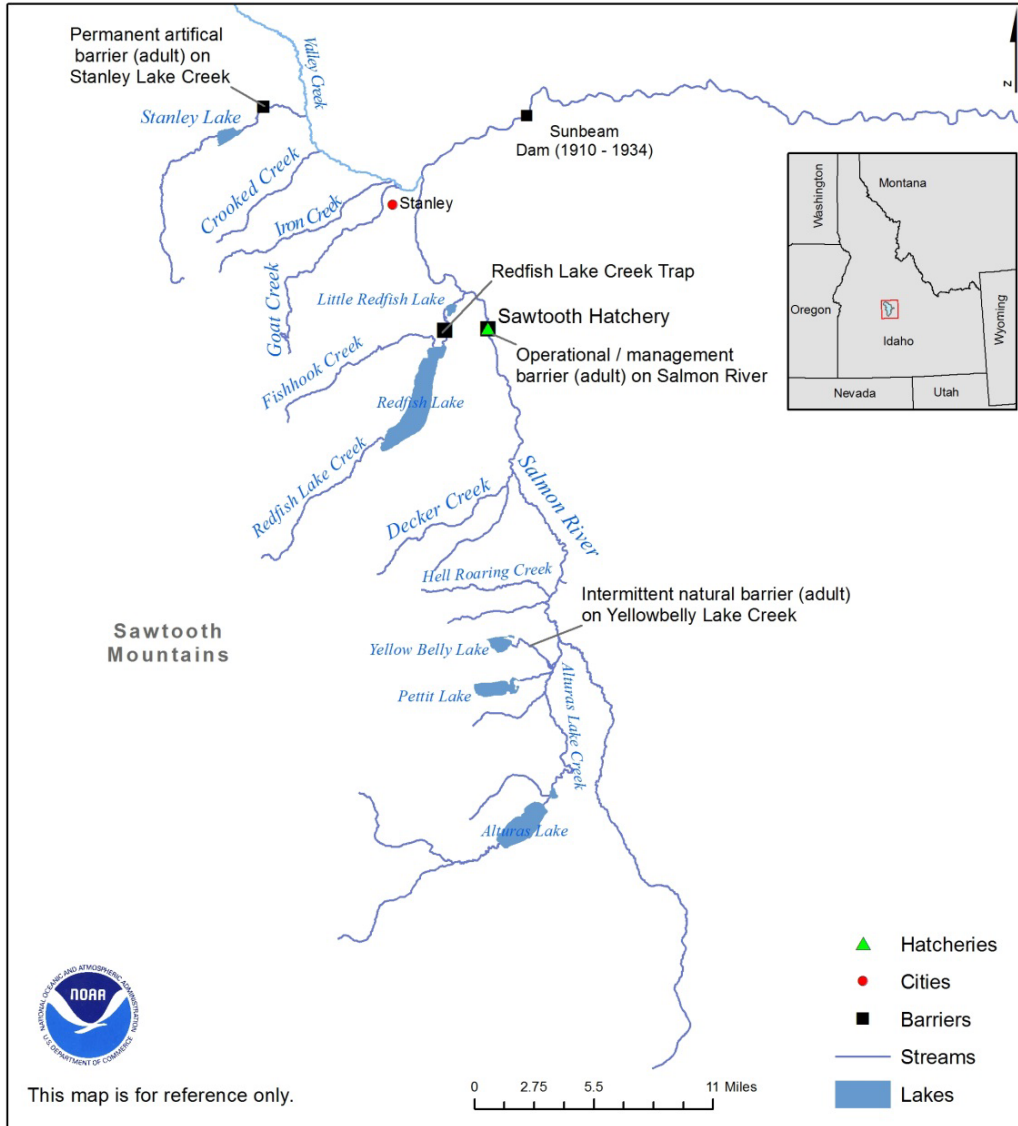


Figure 3-15. Map of the Sawtooth Valley, Idaho [reproduced from (NMFS 2019); Figure 2.13-1]

Most recently, (NMFS 2019) concluded that while total returns of adult sockeye to the Sawtooth Valley have been high enough to allow some natural reproduction in Redfish Lake, the hatchery program is still the primary means to build sufficient returns to support and sustain outplanting and recolonization of the species within its historic range while at the same time prioritizing genetic conservation.

FACTORS AFFECTING THE STATUS OF SNAKE RIVER SOCKEYE

Within the Snake River tributaries that support the spawning and rearing of the SR sockeye population, a variety of limiting factors affect both the species and their habitat. Processes such as climate change contribute to altered water quality and quantity. Anthropogenic activities, e.g., agriculture, forestry practices, and human development have: degraded habitat; impaired fish passage; decreased floodplain connectivity, channel structure, function, and complexity; and reduced riparian area, large woody debris

recruitment, streamflow, and water quality (NMFS 2019). Additional factors that occur during other life phases of the SR sockeye also have profound impacts on the status of the species and include predation, exposure to elevated water temperatures, exposure to elevated TDG levels, fallback at dams, straying to non-natal streams, harvest, and disease (NMFS 2019).

With a decline in salmonid production and a resulting decline in spawners within natal streams, nutrients vital to juvenile production have also decreased dramatically. Gresh et al. (2000) estimated that since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only about 6 to 7 percent of historical levels. They attributed this decline to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. These nutrients are important for salmonid production and consequently for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2002).

Over a total life cycle, the greatest incidence of mortality occurs where SR sockeye salmon spend most of their life, i.e., tributary and early ocean environments (see Section 3.1.1.1, Figure 3-1). Freshwater survival of juvenile sockeye varies depending on habitat and climate conditions, as well as the carrying capacity of the natal lake.

Widener et al. (2019) compiled estimates of survival for juvenile sockeye migrating downstream through the Snake and lower Columbia Rivers. Survival estimates represented empirical estimates for specific geographic reaches, which, depending on the area of inference, could be from the forebay to the tailrace of a specific dam (dam passage survival) or from one dam (e.g., tailrace of McNary Dam) to another dam (e.g., tailrace of Bonneville Dam) (reach survival). Next, we discuss factors affecting the status of SR sockeye by life stage.

Freshwater Spawning, Rearing, and Migration to the CRS

SR sockeye use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. While many of the habitat modification are relics of past anthropogenic practices, NMFS identified factors limiting viability for SR sockeye. Factors limiting this ESU include (1) blocked access to the natal lakes; (2) in the Salmon River—reduced baseflows and altered hydrologic regimes; elevated water temperatures and reduced availability of thermal refugia at tributary confluences due to water withdrawals; presence of toxic compounds with the potential to impair fitness; degraded riparian and instream habitat due to historical and current land use, roads and erosion control, floodplain development, and mining activities; and predation on emigrating juveniles by smallmouth bass, hatchery steelhead, rainbow trout, and brook trout; (3) in the lower Snake River upstream of Lower Granite Dam—altered flows, riparian function, and food webs due to dam operations in the Hells Canyon Complex; degraded water quality; and an altered thermal regime due to land use adjacent to the Snake River and its tributaries; (4) in the mainstem CRS migration corridor—passage barriers, conversion of riverine habitat to reservoirs, and water withdrawals that have degraded habitat conditions; and (5) in the lower Columbia River and estuary—altered food webs, habitat access, and habitat capacity due to dikes and levees that disconnect the river from its historical floodplain and hydrosystem operations that alter flow regimes (NMFS 2019).

Past and present effects of the existence of CRS dams and past operations: SR sockeye salmon are not exposed to the CRS facilities or operations during adult holding, spawning, egg incubation, and juvenile rearing and migration within the lake and tributary environment.

Past and present effects of hatcheries: Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They can also help preserve genetic resources until factors that limit natural productivity 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.

In the case of SR sockeye salmon, the hatchery program has been essential in increasing the numbers of fish returning. In the 2019 BiOp, (NMFS 2019) concluded the following:

The safety net hatchery program for SR sockeye salmon has prevented extinction in the near term and preserved the genetic lineage of Redfish Lake sockeye salmon. The Action Agencies propose to continue to fund this program, which will allow for increased abundance and support the establishment of naturally spawning populations in Sawtooth Valley lakes.

Juvenile Sockeye Downstream Migration through the CRS

As discussed previously, the SR sockeye ESU consists of a single MPG and includes a single population. That population spawns and rears in Redfish Lake, Idaho, and migrates through eight CRS projects to and from the Pacific Ocean.

Past and present effects of CRS existence and operations: Through the CRS, juvenile SR sockeye salmon have been and continue to be exposed to the effects of both CRS operations and the existence of the CRS dams. Juvenile SR sockeye pass downstream of dams by many routes, including spillways and surface passage structures, intake screen bypass systems, and turbine units. Major modifications have been made since 2008 to achieve the 2008 BiOp hydroelectric power generation performance standards and improve fish survival to 96 percent for spring migrants and 93 percent for summer migrants at each of the CRS projects. Due to the limited number of juvenile SR sockeye available for research, no estimates of dam-specific survival have been made for this ESU.

Past modifications of the dams include the installation of surface passage systems, improved turbine designs, upgrades of screened bypass systems to improve how and where fish are returned to the river downstream from dams, and new spill operations tailored to the unique structural configuration of each dam (Bonneville et al. 2017). A summary of those improvements is provided in Appendix D of the *Columbia River System Operational and Structural Improvements under the Endangered Species Act – 2017 Progress Update* and is incorporated by reference here. Briefly, CRS modifications that have likely benefited SR sockeye salmon include the following:

- Minimize winter drafts of the large upper basin storage reservoirs for flood risk management and power generation to save water for augmenting spring flows during the peak juvenile passage period (water quantity).

- Employ JBSs and surface passage structures and provide spill at the run-of-river dams to divert smolts away from turbine units and reduce potential delay in the forebays and minimize predation (safe passage).
- Install replacement turbines with biologically based designs for safer fish passage than the case for the original units.
- Reduce TDG through multiple actions and plans.
- Manage avian and fish predators through multiple actions and plans.

For SR sockeye (hatchery and wild combined) cohort years 1996 or 1998 (depending on reach) to 2018, from Lower Granite to McNary reach, survival was estimated as 0.63; for the McNary to Bonneville reach, survival was estimated as 0.57; and for the Lower Granite to Bonneville Dam reach, survival was estimated at 0.41 (Widener et al. 2019). However, if these estimates are broken into specific time periods, the average reach survival estimate from Lower Granite to McNary, McNary to Bonneville, and Lower Granite to Bonneville for years 1996 or 1998 (depending on reach) through 2008 was 0.56, 0.49, and 0.34, respectively. From 2009 through 2018, survival increases substantially to 0.0.74, 0.75, and 0.56, respectively (Widener et al. 2019) (Table 3-7).

Juvenile SR sockeye salmon are also transported to downstream of Bonneville Dam after being collected at Lower Granite, Little Goose, and Lower Monumental dams. Given their relatively low downstream survival through the CRS (40–71 percent in 2008–14), the transportation program provides a large advantage in the survival of that return as adults back to Bonneville Dam (average transport-to-in-river survival ratio of 2.47). However, upon returning as adults, sockeye salmon that were transported as juveniles tend to spend more time migrating and have a lower upstream survival rate (likely due to increased wandering and resultant interactions with fisheries, and increased fallback rates) than fish that migrate in-river as juveniles in the Bonneville to McNary Dam reach.

Table 3-7. Estimated survival for SR sockeye salmon (hatchery and wild combined) for the Lower Granite to McNary, the McNary to Bonneville, and the Lower Granite to Bonneville reaches for 1996 to 2018

Year	Annual Survival Estimates for Snake River Sockeye		
	LWG to MCN	MCN to BON	LWG to BON
1996–2018 Average:	0.628	0.566	0.406
1996–2007 Average:	0.558	0.488	0.343
2008–2018 Average:	0.698	0.630	0.455
2008–2018 Average (Excludes 2015–2017):	0.738	0.745	0.555

Table based on (Widener et al. 2019); Table 32a; Page 60.

Elevated TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can get forced into solution when water passes over the spillway at a mainstem dam, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem

dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019). Because SR sockeye salmon are susceptible to GBT, they benefit from the gas abatement structures.

Past and present effects of predator management: Survival of SR juvenile sockeye is affected by avian and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple 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. These efforts have reduced avian and piscivorous predation on juvenile salmon and steelhead at the dams (NMFS 2019).

Juvenile Sockeye Estuary Migration and Rearing, Including the Plume

The estuary provides important migratory habitat for SR sockeye populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also affected estuary ecosystems. For a more detailed discussion of estuary and plume conditions, see (NMFS 2019). All of these conditions are part of the environmental baseline.

Past and present effects of CRS existence and operations: While there are no CRS facilities in the estuary (defined as Bonneville Dam to the ocean), past CRS management affected the timing and volume of flows, as well as temperature, sediment load, and TDG levels in this area. The effects of CRS management actions generally decrease as distance from Bonneville Dam increases and estuary hydrodynamics become less fluvially influenced. In particular, flow regulation and reduced sediment recruitment caused by the CRS have likely negatively affected habitat-forming processes in the estuary, habitats which support the juvenile life stage of all Columbia River Basin anadromous fish populations.

Estuarine floodplain habitat is important for outmigrating juvenile salmonids, including SR sockeye. To help maintain and improve the overall status of salmon and steelhead in the Columbia River Basin, the Action Agencies actively work to restore and conserve habitat in the Columbia River estuary through CEERP. These restoration actions affect salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit of estuary restoration is that wetland food production supports foraging and growth within the wetland [Johnson et al. (2018) as cited in NMFS (2019)]. Prey items (primarily chironomid insects and corophiid amphipods; [PNL/NMFS (2018) as cited in NMFS (2019)] produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest 5-year review of CEERP (Johnson et al. 2018), have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide-gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity

below Bonneville Dam [Johnson et al. (2018) as cited in NMFS (2019)]. In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past and present effects of predation management: A variety of avian species (especially Caspian terns and double-crested cormorants), have historically been a major source of predation on juvenile salmonids in the estuary. While avian predators continue to prey upon juvenile salmonids, including SR sockeye, predation rates have declined due to a variety of management efforts. For example, between 2007 and 2010, the average predation on SR sockeye by Caspian terns and double-crested cormorants from East Sand Island (in the lower estuary) was approximately 1.5% and 3.6%, respectively (Evans et al. 2018). However, from 2011 to 2017, the average for Caspian terns dropped to 1.4% (Evans et al. 2018). The efforts to reduce avian predation are discussed in detail within the 2019 BiOp and are incorporated by reference here (NMFS 2019). (NMFS 2019) has noted the success of implementing the avian management plans at meeting underlying goals; however, the results may be uncertain at this time because some cormorants and terns have relocated to other areas within the estuary.

Ocean Rearing

SR sockeye salmon typically reside in the ocean for 2 years but can spend 1 to 3 years in nearshore and open-ocean habitats (Bjornn et al. 1968; Farley Jr. et al. 2018). In the most recent adult return years, abnormally warm ocean temperatures and subsequent poor ocean conditions have contributed to declines in ocean survival and associated adult returns. (NMFS 2019) provides a detailed discussion on ocean conditions, factors that affect the ocean environment, and impacts to SR sockeye. That information is incorporated here by reference; a brief summary of those factors follows.

Factors that influence ocean conditions are also likely to affect survival of SR sockeye salmon. The consequences of climate change will likely include increased water temperatures, more severe El Niño events, worsened ocean acidification, and major alterations in the northeast Pacific Ocean marine ecosystem associated with the PDO (NMFS 2019). These factors will affect SR sockeye salmon survival either directly or indirectly because of deleterious impacts on marine food webs.

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in distribution of aquatic marine organisms. Many species that typically occur in more southerly waters moved northward from southern California to Alaska in the unusually warm water during 2014 and 2015, which was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Nino events [Pearcy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt marine ecosystems in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean, and past CRS operations have had no direct effect on this ESU during ocean residence. Welch et al. (2018) concluded that marine survival of west coast Chinook and steelhead populations has collapsed over the last half century for most regions of the west coast. Based on their review of annual survival estimates for Chinook and steelhead, they concluded the following:

We found that marine survival collapsed over the past half century by a factor of at least 4-5-fold to similar low levels (~1%) for most regions of the west coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Another factor that should be considered is delayed, or latent, mortality. Delayed mortality is a term for harm caused when an animal survives one event or circumstance but incurs damage that only shows up later and may be expressed as illness or death. With Columbia River Basin salmon and steelhead, the term is commonly applied in situations such as barging or dam passage of salmon or steelhead smolts. The term “latent mortality” is generally used more specifically to apply to the effects of dam passage. While most or all of the fish might survive the act of migrating in-river past the dam, the delayed mortality hypothesis holds that, as a result of passing a dam, a smolt is less healthy than it would be otherwise and therefore less likely to survive in the ocean and return as an adult.

ISAB (2012) concluded, after reviewing various studies, that their analyses demonstrated that fish bypass systems are associated with some latent mortality, but the factors responsible for latent mortality remain poorly understood and are inadequately evaluated—further:

The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis).

Past and present effects of harvest: SR sockeye are seldom caught in ocean fisheries. (NMFS 2019) stated that ocean-fishing-related mortality for this ESU is assumed to be zero.

Adult Sockeye Migration to Bonneville Dam

Adult sockeye migrating upstream after ocean residence typically do not feed within the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume and a migration corridor free of obstructions to access spawning areas (NMFS 2019). SR sockeye enter the Columbia River estuary primarily in June and July and migrate upstream from Bonneville Dam in late June and July, with the median date of arrival at Bonneville Dam ranging between June 29 and July 5 for the years 2008 through 2013 (Bjornn et al. 1968; Crozier et al. 2014).

For upstream migrating SR sockeye, a likely factor affecting survival to Bonneville Dam is pinniped predation. While estimates of pinniped predation downstream of the Bonneville Dam tailrace are not available for adult sockeye, salmonid consumption by California sea lions, Stellar sea lions and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). The ODFW has been counting the number of individual sea lions hauling out at the East Mooring Basin in Astoria, Oregon, since 1997. Data show that pinniped abundance within the Columbia River during the peak of the adult SR sockeye salmon run in June have increased substantially in recent years, from about 45 pinnipeds in 2008–2009 to over 500 in 2014–2017 (Wright et al. 2018). Upstream migrating sockeye salmon are likely encountering outmigrating pinnipeds as they move toward breeding grounds outside of the Columbia

River Basin. There are no estimates of the proportion of sockeye salmon consumed by pinnipeds in the Columbia River; however, the overall impact of pinniped predation on salmon is likely related to overall pinniped abundance. Wargo Rub et al. (2019) found evidence that recent increases in pinniped abundance in the Columbia River have likely resulted in increased predation of sockeye salmon in recent years.

Other researchers confirm that the abundance of pinnipeds in the Bonneville Dam tailrace has increased over the last 6 years (Tidwell et al. 2018). In a subsequent study, Tidwell et al. (2018) documented an average of 14.5 Stellar sea lions between July 21 and December 31, 2017, and on numerous occasions observed more than 20 individuals. Wargo Rub et al. (2019)], found evidence that recent increases in pinniped abundance in the Columbia River have likely resulted in increased predation of sockeye salmon in recent years.

Past and present effects of CRS dams and operations: There are no CRS dams that impede migration in the estuary as these fish migrate upstream to Bonneville Dam. As mentioned previously, adult SR sockeye migrate upstream through the estuary and typically arrive at Bonneville Dam in late June to late July, with the median date of passage occurring in late June to early July. The Action Agencies are required to spill water over the CRS dams to increase survival of juvenile fish migrating downstream during that time. As such, adults may be exposed to higher levels of TDG, which may influence their migration behavior or increase their chances of GBT (NMFS 2019). TDG levels are mitigated to some extent downstream from Bonneville Dam due to gas dissipation and to mixing of water with low TDG levels from tributaries downstream of Bonneville Dam.

Past and present effects of harvest: The 2018–2027 U.S. v. Oregon Management Agreement provides a framework to manage the salmon and steelhead fisheries and hatchery programs in most of the Columbia River Basin. For sockeye in the lower Columbia River (upstream to the Highway 395 bridge spanning the Columbia River), the agreement stipulates that impacts associated with non-treaty commercial and recreational fisheries will be minimized to the extent possible; however, the total impact will not exceed 1% of the run as measured at the mouth of the Columbia River. For treaty commercial fisheries, allowable impacts are based on a sliding scale, and allow harvest rates of 5–7% on SR sockeye. These conditions are consistent with the prior management agreement for SR sockeye (U.S. v. Oregon 2008).

(NMFS 2019) states that, while the reported harvest rate of SR sockeye is within the overall eight percent cap, the overall mortality rate associated with the fisheries may be greater. NMFS cites the relatively high adult mortality rates observed in the lower Columbia River relative to the Snake River as a possible indicator of those impacts. Also, they cite observed gill net injuries at Lower Granite Dam that averaged 11% for the years 2009 to 2016 [excluding 2013 and 2015; range 3.1 to 26.3%; NMFS (2019)]. Harvest mortality in fisheries downstream of Bonneville Dam has been reduced substantially in response to evolving conservation concerns and restrictions for ESA-listed species

Adult Sockeye Migration Through CRS Dams

SR sockeye migrate upstream through all eight lower Columbia and Snake River CRS projects on their way to spawn. During upstream migration, these fish experience a variety of factors that affect the adult migration life stage, including harvest, dam passage, pinniped predation, and temperature and flow

conditions that can increase the energetic demands of migrating fish [NMFS (2008b); Keefer et al. (2016); and Keefer and Caudill (2017) as cited in NMFS (2019)]. The primary factors influencing safe, timely, and effective adult upstream passage through CRS dams are tailrace flow dynamics and sufficient attraction flows to fish ladder entrances, as well as operating ladders within criteria, reducing fallback, and maintaining safe ladder temperature and differentials (NMFS 2019).

Past and present effects of CRS existence and operations: Under typical conditions, adult SR sockeye have relatively high survival rates passing the Snake River CRS dams, and to a lesser extent, the lower Columbia River CRS projects. Between 2008 and 2014, the average survival rate of adult SR sockeye in the Bonneville Dam to McNary Dam reach was 71.9%. For the McNary to Lower Granite reach, survival averaged 89.2 percent. Overall for that time-series, survival from Bonneville Dam to Lower Granite Dam averaged 63.3 percent (Crozier et al. 2015).

These estimates of minimum survival also account for impacts associated with fallback at the CRS projects, such as direct and indirect mortality due to the fallback event, delay, straying, etc. The mean annual fallback rates at the lower Columbia River dams has been estimated to be 2.9 to 38.1 percent (NMFS 2019). Based on the relatively high survival estimates, NMFS concluded that upstream passage conditions for adult SR sockeye are not substantially impaired as fish migrate through the lower Columbia and Snake Rivers (NMFS 2019).

Water is released from Dworshak Dam in the summer to reduce temperatures in the Snake River to reduce potential negative effects of increased water temperature on upstream migrating adult salmon and steelhead. Operators manage the Dworshak project so temperatures do not exceed 68°F at the tailrace of Lower Granite Dam. These releases substantially cool the lower Clearwater River and Lower Granite Reservoir.

Despite the benefits of cool water releases from Dworshak Dam, water temperatures in the forebay of Lower Granite Dam exceeded 25 degrees Celsius in the summer of 2015. These temperatures were the result of an extended heat wave causing water temperatures in Snake River tributaries above Lower Granite Dam to be excessively high. These high water temperatures were dangerously stressful to adult sockeye salmon and resulted in an emergency operation to trap and haul adult Snake River sockeye before being spawned at Eagle Fish Hatchery or released into natal lakes in the Sawtooth Valley. These temperature conditions have not been observed in the recent historical record (i.e., since 1949 in the mainstem river and 1956 in the tributaries). However, it is reasonable to expect that similar events could occur in the future because of climate change and the impact on sockeye salmon populations in the Columbia River basin could be substantial (NMFS 2016c).

Past and present effects of predator management: As discussed previously, the presence of pinniped predators has increased within the Bonneville Dam tailrace in recent years, with occasional pinniped observations in the Bonneville Reservoir when SR sockeye are present [Tidwell et al. (2018) as cited in NMFS (2019)]. To restrict entry of pinnipeds into the ladder systems at Bonneville Dam, the Corps has constructed structures to physically exclude pinniped entry into fishways, while allowing upstream migration of adult salmonids. These structures have been installed within all eight fishway entrances at Bonneville Dam.

Average pinniped impacts to summer migrating adult SR sockeye are likely relatively small because pinniped counts are generally decreasing in July and August (when most SR sockeye pass Bonneville Dam) (NMFS 2019).

Past and present effects of harvest: The 2018–2027 U.S. v. Oregon Management Agreement provides a framework to manage the salmon and steelhead fisheries and hatchery programs in most of the Columbia River Basin. For sockeye in the lower Columbia River (upstream to the Highway 395 bridge spanning the Columbia River), the agreement stipulates that impacts associated with non-treaty commercial and recreational fisheries will be minimized to the extent possible; however, the total impact will not exceed one percent of the run as measured at the mouth of the Columbia River. For treaty commercial fisheries, allowable impacts are based on a sliding scale, with harvest rates of five to seven percent on SR sockeye. These conditions are consistent with the prior management agreement for SR sockeye (U.S. v. Oregon 2008).

Within the 2019 BiOp, NMFS states that while the reported harvest rate of SR sockeye is within the overall eight percent cap, the overall mortality rate associated with the fisheries may be greater. NMFS cites the relatively high adult mortality rates observed in the lower Columbia River relative to the Snake River as a possible indicator of those impacts. Also, they cite observed gill net injuries at Lower Granite Dam that averaged 11 percent for the years 2009 to 2016 (excluding 2013 and 2015; range 3.1 to 26.3 percent (NMFS 2019)).

Adult Sockeye Migration Upstream of the CRS to the Spawning Areas

Within the Snake and Salmon Rivers, the main migratory corridors for SR sockeye upstream of the CRS, a variety of limiting factors affect this ESU's ability to reach natal spawning lakes and successfully reproduce. Processes such as climate change have contributed to altered water quality and quantity. In the Snake River upstream from Lower Granite Dam, limiting factors include altered flows, degraded riparian function, degraded water quality, and altered thermal regimes. Within the Salmon River, limiting factors include degraded water quality (volume, temperature, and pollutants) and degraded riparian and in-stream habitat. In the Sawtooth Valley, access to natal lakes has been blocked or hindered, and sediment loads into those lakes have increased due to historical land use, such as mining, sheep and cattle grazing, timber harvest, and road building in the watersheds surrounding the lakes. Also, flow has been reduced and migration blocked due to irrigation withdrawals and diversions (NMFS 2019).

STATUS OF CRITICAL HABITAT

SR sockeye critical habitat includes the stream channels within designated stream reaches and to an extent defined by the ordinary high-water mark (33 CFR § 319.11). The PBFs of critical habitat essential to the conservation of SR sockeye include freshwater spawning and juvenile rearing areas, adult and juvenile migration corridors, and areas for growth and development to adulthood (Table 3-8) (NMFS 2019).

Critical habitat for the SR sockeye ESU was designated on December 28, 1993 (58 FR 68543 ; NMFS 2016a). Critical habitat has been designated for the SR sockeye juvenile and adult migration corridors to the Pacific Ocean and includes the lower Columbia River and its estuary, the Snake River to the Salmon

River confluence, and the mainstem Salmon River up to the Sawtooth Valley in Idaho. Historical nursery areas essential to the conservation of this ESU and identified as critical habitat include Redfish, Alturas, Pettit, Stanley, and Yellow Belly lakes, as well as their inlet and outlet creeks; Alturas Lake Creek; and the portion of Valley Creek that lies between Stanley Lake Creek and the Salmon River.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation 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.

Table 3-8. PBFs and components and principal factors affecting the environmental baseline of critical habitat designated for SR sockeye [based on NMFS (2019); Table 2.13-2; Page 583].

PBFs	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBFs
Freshwater spawning sites	Water quantity and quality conditions and substrate supporting spawning, incubation, and larval development	Blocked access to natal lakes Effects on food webs (predators and prey) in the natal lakes from the introduction and continued stocking of non-native fishes such as brook trout, rainbow trout, lake trout, and kokanee Increased sediment inputs from historical land use, mining practices, sheep and cattle grazing, timber harvest, and road building in the watersheds surrounding the natal lakes
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 supporting juvenile development 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	Blocked access to natal lakes Effects on food webs (predators and prey) in the natal lakes from the introduction and continued stocking of non-native fishes such as brook trout, rainbow trout, lake trout, and kokanee Increased sediment inputs from historical land use, mining practices, sheep and cattle grazing, timber harvest, and road building in the watersheds surrounding the natal lakes
Freshwater migration corridors	Free of obstruction and excessive predation Adequate water quality and quantity Natural cover	Delay and mortality of adults (at up to eight mainstem dams) Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting)

PBFs	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBFs
Estuarine areas	Not designated	Although (58 FR 68543 1993 (2006 correction)) recognized that the Columbia River estuary was an essential rearing area and migration corridor for SR sockeye salmon and designated the estuary as critical habitat, it did not define essential PBFs unique to this portion of the designated area. Instead, NMFS considers the estuary part of the juvenile and adult migration corridors (NMFS 2019)
Offshore marine areas	Not designated	

As discussed previously, adult SR sockeye salmon enter the Columbia River in June and July, migrated upstream through the Snake and Salmon Rivers, and arrive at their natal lakes in the Sawtooth Valley primarily in August, and to a lesser extent, early September (Bjornn et al. 1968). Migration timing has not been altered substantially by the adults migrating upstream past the eight mainstem Columbia River and Snake River dams (NMFS 2019). During their freshwater migration, adult sockeye 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 2019).

SR sockeye spawn in lakeshore gravels, peaking in October, with fry emerging in late April through May the following year (Chapman et al. 1990). 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 from the gravel. Eggs also require cool, clean, and well-oxygenated waters for proper development. Shortly after emergence, sockeye fry move to a nursery lake, where they need the ability to migrate vertically and horizontally to avoid predators and forage for food (plankton) for 1 to 3 years before migrating to the ocean. Juvenile sockeye salmon generally leave the Sawtooth Valley lakes during late-April through May and migrate nearly 900 miles to the Pacific Ocean (Bjornn et al. 1968).

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of SR sockeye. Spawning and rearing currently occur in Redfish Lake.

The quality of spawning and rearing habitat for SR sockeye in the Sawtooth valley and Stanley basin is impaired by barriers blocking or hindering access to natal lakes and increased sediment loads into those lakes due to historical land use, such as mining, sheep and cattle grazing, timber harvest, and road building in the watersheds surrounding the lakes (NMFS 2019).

Freshwater Migration Corridor

The freshwater migration corridor for SR sockeye salmon extends from Redfish Lake in the Sawtooth Valley, Idaho, downstream to the Columbia River plume. Migration corridors are considered essential to the conservation of SR sockeye. Human activities that have affected habitat in subbasin tributary reaches have already been discussed and contribute to the quality and quantity of water downstream and within the freshwater migration corridor. Tributary habitat actions that have already been implemented support all Snake River salmonids and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, removing barriers to spawning and rearing habitat, and other actions targeted toward addressing limiting factors (NMFS 2019). There are no CRS projects on the mainstem Salmon River, but they are found on the tributaries to the Snake and Salmon rivers. SR sockeye are not exposed to CRS operations until they reach the mainstem Snake River Reservoir created by the first dam they encounter, Lower Granite Dam.

The quality of designated critical habitat within the Columbia River migration corridor is a function of the cumulative impacts of both local and upstream actions, including impacts from development along the corridor, dam existence and operations, and management within the Snake and Columbia Rivers that affects both juvenile and adult SR sockeye. All these factors combine to affect critical habitat in the mainstem and influence the migration corridor. Mainstem river habitat has been substantially altered by a number of factors, including basin-wide water management, the construction and operations of CRS projects, increased avian and pinniped predators, the introduction of non-native species, and other human-related activities that have degraded water quality and habitat (NMFS 2019). (NMFS 2019) describes those factors affecting the behavior and survival of SR sockeye through the CRS, and that information is incorporated here by reference (NMFS 2019). The following briefly summarizes that information.

Mainstem dams and dam operations can affect stream temperature, streamflow, gas supersaturation levels, and river habitats. Both the Snake and Columbia Rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Because the temperature regime has been modified, resulting in cooler late spring/early summer and warmer late summer/fall water temperatures, it potentially affects juvenile and adult salmonids as well as fish community structure. Warmer stream temperatures later in the year may influence predation rates on juvenile fish by predatory fish species. Juvenile fish may also be affected when water is spilled, whether voluntarily or involuntarily, from hydroelectric facilities that increase gas supersaturation and may lead to GBT in fish. All projects create impoundments that affect riverine habitats and can affect travel times, which in turn may increase juvenile fish exposure to both native and non-native predators. Some passage routes through dams may decrease juvenile fish survival (e.g., turbines) compared to spill bays and surface passage routes that are operated to increase overall juvenile passage survival. The processes, general effects, and mitigation of CRS mainstem dams and dam operations on the functioning of critical habitat are shown in Table 3-9.

Table 3-9. The processes and effects of the CRS dams and dam operations, as well as mitigation efforts to address the effects

Process	Effect	Avoidance, Minimization, or Mitigation Measure
Passage at dams	Reduced juvenile survival due to the existence of the dams (baseline), recent improvements in survival since CRS overhaul	Surface passage, increased proportion of spill, flow augmentation, TDG management, bypasses, and fish-friendly turbines
Water storage operations	Altered water quantity and seasonal timing	Flow augmentation
Solar radiation/reduction in mainstem stream velocity	Altered temperature for late summer and fall fish migrants, both in the reaches below the large mainstem storage projects and migration corridors	The dams result in water temperatures that are slightly better (cooler) during the spring migration
Spill	Increased TDG	System-wide TDG management
Modification (impoundment and water level fluctuation) of mainstem migratory and rearing habitat	Altered food webs, including both predators and prey due to the existence of the dams and to a lesser extent the ongoing operations of the CRS	Avian management, fish bypass outfall placement (away from known predator concentrations), and pikeminnow removal (management)

Since 2008, when modifications to the physical and operational CRS system were implemented in accordance with the 2008 BiOp, survival of SR sockeye juvenile and adult migrants has improved substantially. For adult SR sockeye, recent (2013–2017) survival rates have averaged about 60 percent from Bonneville to McNary Dam and about 50 percent from Bonneville to Lower Granite Dam (NMFS 2019). This includes the extremely poor survival year of 2015, when only 15 percent of adult SR sockeye salmon survived from Bonneville to McNary Dam, and only four percent survived from Bonneville Dam to Lower Granite Dam.

One example of efforts to improve adult Sockeye survival is the emergency response to high temperatures. From July 13 to August 05, 2015 water temperatures in the forebay of Lower Granite Dam (LGR) exceeded 25°C at a 3-meter depth, temperature at the Anatone gauge located upstream of LGR Dam exceeded 24°C, and temperature at Whitebird gauge on the Salmon River exceeded 25°C. Temperatures were dangerously stressful to (endangered) Snake River (SR) Sockeye adults. Monitoring showed: 1) water temperatures increasing into the lethal range for salmonids, 2) significant declines in adult sockeye conversion rates between dams and increasing fallback rates, and 3) large numbers of dead or dying sockeye in cool water refuges. To increase their chances of survival, an adult SR sockeye salmon passage emergency operation was declared on July 13th, 2015. Adult sockeye from the LGR Dam fish ladder were trapped and transported to the Eagle Fish Hatchery for holding until their final disposition could be determined (i.e. spawned in the hatchery or released into the natal lakes in the Sawtooth Valley for natural spawning). Emergency trapping ended August 5th, 2015 when fewer than five fish were observed in the counting window and few or no adults were expected to enter the trap. With few exceptions, trapping occurred in morning hours, from 7:00 am to 11:30 pm each day, when adults were actively moving. A total of 51 adult sockeye were collected. There were no mortalities

during trapping or transport. These June and July 2015 temperature conditions have not been observed in the recent historical record (i.e., since 1949 and 1956, respectively). However, it is reasonable to expect that similar events could occur in the future because of climate change and the impact on sockeye salmon populations in the Columbia River Basin could be substantial (NMFS 2016c).

Estuarine and Nearshore Marine Areas

Critical habitat has been designated for SR sockeye in the Columbia River estuary (58 FR 68543, Dec. 28, 1993). NMFS has defined the estuary to include the reach where river flows interact with tidal forces. As defined, that area includes the lower Columbia River from the Bonneville Dam tailrace (RM 146) to the mouth of the Columbia River, and includes tributaries influenced by tidal action. As such, the lower 26 miles of the Willamette River is included within the estuary domain.

(NMFS 2019) considers a functioning estuary to be essential to the conservation of SR sockeye. Furthermore, NMFS identified the PBFs for SR sockeye in estuaries to include areas free of obstruction with water quality, 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, that supports growth and maturation (NMFS 2019).

Degraded habitat conditions in estuarine and nearshore marine areas were identified as limiting factors for SR sockeye (NMFS 2019). Historically, the Columbia River estuary was more dynamic than it is today. Multiple channels, extensive wetlands, sandbars, and shallow areas, especially in the downstream 50 RM, were influenced by winter and spring floods, low flows in late summer, large woody debris, and high sediment loads (NMFS 2019). As reported by NMFS (2019), the current conditions of the Columbia River estuary have changed as a result of many factors, including dredging to deepen and maintain the Federal Navigation Channel and construction of jetties and pile-dike fields to stabilize and concentrate river flow. Causeways have been constructed across waterways. As noted by (NMFS 2019), the mouth of the Columbia River was historically about four miles wide but has decreased to about two miles wide, and the depth has increased at the bar of the Columbia River channel from less than 20 feet to more than 55 feet.

The estuary provides important migration habitat for SR sockeye. In particular, (NMFS 2019) reported a dramatic decrease in wetland areas in the Columbia River estuary. More than 50 percent of the marshes and spruce swamps have been converted to industrial, transportation, recreational, agricultural, or urban areas, with more than 3,000 acres converted since 1948 (NMFS 2019). In the upper reaches of the estuary, many wetlands on the floodplain have been converted to industrial and agricultural lands after levees and dikes were constructed. As reported by (NMFS 2019), 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost since the late 1800s. Those wetlands support salmonid food webs both in shallow water and in the mainstem.

Changes in streamflow and sediment delivery have also affected critical habitat in the Columbia River estuary. NMFS reports that water storage and release patterns from reservoirs upstream have changed the seasonal pattern and volume of discharge within the Columbia River estuary (NMFS 2019). Discharge has increased in the winter, and peak spring/summer floods have been reduced. (NMFS 2019) also reported that model studies indicate that combined human activities in the Columbia River Basin have

decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine-sediment transport by 50 percent or more. The significance of changes in sediment delivery to SR sockeye is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean, and subyearlings that may spend months in the estuary [Johnson et al. (2018); PNPL/NMFS (2018); and Weitkamp (2018) as cited in NMFS (2019)].

In terms of critical habitat, there are no CRS-related barriers to migration in the estuary, and there is no evidence that flows are insufficient for migration.

PROPOSED ACTION COMPONENTS SPECIFIC TO SNAKE RIVER SOCKEYE

The Proposed Action, which is continuing to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2, Proposed Action. Reclamation is also consulting on the Columbia River mainstem effects of six irrigation projects that also have additional and separate ESA review.⁵ This Proposed Action continues extensive operations that benefit SR sockeye, including flow augmentation, spill, surface passage, intake bypasses, and adult ladder operations. In addition, mitigation activities implemented under previous BiOps will continue, including tributary and estuary habitat improvements; fish, avian, and pinniped predator management; and conservation and safety-net hatcheries (see Chapter 2). The Action Agencies will continue to coordinate with regional sovereigns and will regularly update plans for water management, fish passage, fish operations, and water quality. The Action Agencies intend to implement these actions commencing in September 2020.

SR sockeye are exposed to the effects of the existence and operation of the CRS as follows:

- Streamflow quantity and TDG changes from the Clearwater confluence with the Snake River and from the confluence of the Snake River with the Columbia River and to the ocean;
- Passage through eight CRS dams in both the downstream and upstream migrations.

Mitigation for these effects that is part of the action includes: flow augmentation; spill regimes at eight dams; cool water releases from Dworshak Reservoir during the summer migration period; juvenile fish transportation; fish facility operations at eight dams (bypasses, ladders, surface structures, outfalls, etc.); operation of fish-friendly turbines at McNary and Ice Harbor Dams; avian, fish, and pinniped predator management; tributary habitat actions that; and estuary habitat actions.

EFFECTS OF THE ACTION ON SNAKE RIVER SOCKEYE

The main effects on SR sockeye salmon of continuing to operate and maintain the CRS include mitigating the effects of the baseline migratory impediments caused by the existence of the CRS mainstem Columbia and Snake River dams, by supporting downstream and upstream passage. Action effects also

⁵ Columbia River mainstem effects of certain Reclamation irrigation projects are included in this CRS consultation because the Columbia River hydrologic modeling incorporates all such impacts. The mainstem Columbia River impacts are included for the Yakima, Umatilla, Deschutes, Crooked River, Dalles, and Chief Joseph irrigation projects. The flow impacts of these projects to the mainstem Columbia River are fully integrated in discussions of flow and TDG in the parts of the migratory corridor both used by this ESU and impacted by these projects.

include changes in fish travel time based on upriver reservoir storage operations, as well as potential exposure to elevated TDG from voluntary spill. Improving juvenile and adult migration survival has been the focus of mitigation actions under past BiOps, and the benefits of these actions have been thoroughly documented (Corps et al. 2017a; Bonneville et al. 2018b). These already-completed actions will continue to provide benefits in the future. The effects of the Proposed Action on this ESU and its critical habitat are described by life stage below.

Freshwater Spawning, Rearing, and Migration to the CRS

In spawning and rearing areas, fish are not exposed directly to the effects of the operation of the action because they are far removed from the influence of CRS water management operations. Because none of these operations are components of the Proposed Action, there are no direct effects from managing the CRS to individual fish in these areas.

Some individual fish of this ESU are exposed to habitat improvements through the Tributary Habitat Improvement Program, which is a component of the Proposed Action. SR sockeye salmon will benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that will result from the tributary actions. Adverse effects to individuals from actual implementation (i.e., construction) of habitat enhancement actions are mitigated through compliance with the Tributary Habitat Improvement Projects BiOp (NMFS 2013; USFWS 2013) and site specific compliance documents. Tributary habitat improvements are proposed for the Snake River tributaries that support SR sockeye salmon and include streamflow protection and enhancement, improved habitat access, improved stream complexity, improved riparian habitat, and improved screening to reduce entrainment, all of which continues to improve habitat conditions over the baseline condition.

Juvenile Sockeye Salmon Downstream Migration through the CRS

Juvenile SR sockeye salmon are not exposed to the effects of CRS operations until they reach the mainstem Snake River. In this migration corridor, juvenile SR sockeye salmon will continue to experience the deleterious impacts of a degraded environmental baseline, including the existence of dams, and associated cumulative effects, unless they are transported.

Operational and structural improvements have been made to the specific conditions and structure of each dam to reduce the proportion of juvenile fish that passes through turbines, reduce forebay passage delay, and improve overall dam passage survival (Corps et al. 2017a).

In general, the Proposed Action will continue operations and implement actions to minimize impacts from both baseline conditions and the action, and thus increase survival of juvenile SR sockeye salmon that pass through the CRS. Measures that have been implemented and will continue include flow augmentation, voluntary spill, and other measures to direct juveniles away from turbines, (e.g., through spill, surface passage, and other juvenile bypasses), safer turbine passage, transportation, and predator management.

Changes in the Proposed Action compared to past operations include a flex spill operation and changed implementation of summer spill. Because juvenile SR sockeye salmon do not migrate during the summer, any changes in summer spill will not affect this ESU. Changes to spring spill could result in

increased juvenile passage survival for SR sockeye salmon that are passing through the CRS and also decreased latent mortality.

A more detailed analysis of effects to SR sockeye salmon as a result of implementing the Proposed Action during downstream migration through the CRS is described below.

Operational

Survival at CRS Dams

Survival of juveniles once they enter the Snake and Columbia River is influenced by a suite of factors— passage conditions at mainstem dams, flow conditions, water quality (e.g., temperature, TDG), predators, and fish travel time. Survival studies show, with few exceptions, that measures implemented through previous BiOps and continued into the current Proposed Action performed as desired and have, or are very close to achieving, the 2008 BiOp juvenile dam passage survival objective of 96 percent for juvenile sockeye salmon (NMFS 2017a). Due to the limited number of juvenile SR sockeye available for research; however, no estimates of dam-specific survival have been made for this ESU.

While turbine survival is generally lower than spillway survival, bypass and sluiceway survival can be close to, equal to, or even greater than spillway survival in terms of direct dam survival. We anticipate that increases in spillway passage associated with spring flexible spill may result in increased reach survival. It is important to note that since higher spill levels result in unbalanced energy and 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, though most predictions are for increased survival.

Comparing annual estimated survival during the post-2008 BiOp period (2009–2016) to the pre-2008 BiOp period (beginning in 1996 or 1998, depending on reach) indicates that the average estimated survival has increased. For three reaches (Lower Granite Dam to McNary Dam, McNary Dam to Bonneville Dam, and Lower Granite Dam to Bonneville Dam, survival from 1996 or 1998 to 2008 averaged 0.58, 0.50, and 0.35, respectively, and increased to 0.69, 0.64, and 0.46 from 2009 to 2018, respectively. Implementation of the Proposed Action is expected to maintain or improve survival of SR sockeye salmon migrating through the system and reduce any potential latent/delayed mortality after they pass Bonneville Dam.

Transportation

Upon returning as adults, sockeye salmon transported as juveniles tend to spend more time migrating and have a lower upstream survival rate (likely due to increased wandering and resultant interactions with fisheries, and increased fallback rates) than fish that migrate in-river as juveniles in the Bonneville to McNary Dam reach. Both the Northwest Fisheries Science Center (NWFSC) and the Fish Passage Center have estimated the percentage of SR sockeye salmon transported during the years 2013 to 2017. The NWFSC mean estimate for these years is 34 percent (range 26-51 percent) (Smith et al. 2018) while the Fish Passage Center estimate is 39 percent (range 8-58 percent) (DeHart 2018). The two estimates are based on different estimation methods.

Mainstem Columbia River Fish Travel Time

Under the flex spill plan, spring spill operations at the eight run-of-river dams will spill to state water quality limits for 16 hours per day (anticipate 125 percent starting in 2020) and at performance spill for 8 hours per day. The main effect of the higher spill is a decrease in forebay delay and an increase in spill passage efficiency, with a hypothesized reduction in latent mortality (NMFS 2019). This results in shorter forebay residence times. Based on modeling results for SR spring/summer Chinook salmon, travel time for SR sockeye salmon from McNary Dam to Bonneville Dam will be slightly reduced. Additional flow through the spill bays will likely draw a greater proportion of juvenile sockeye salmon migrants from the powerhouse routes (turbine and bypass) and surface passage routes (surface weir and sluiceway). Decreasing juvenile salmonid travel time with higher levels of spill through the CRS can provide a survival advantage by reducing exposure time to predators and fostering a more normative synchrony between the physiological process of smolt transformation and the timing of ocean entry.

Powerhouse Passage Proportion

In addition to increasing spill in the spring, the Action Agencies propose to modify spillway weirs and turbines at Ice Harbor, McNary, and John Day Dams. These actions to improve the baseline structural conditions are anticipated to increase survival of juvenile fish that pass through those routes. In addition, increasing the proportion of water discharged as spill directs a higher fraction of migrants away from the powerhouse and toward the less hazardous spillway. This reduces smolt encounters with turbines and the intake screen bypass system, both of which have been implicated in contributing to potential latent/delayed mortality as expressed in the marine environment. It is also possible that reduction in powerhouse encounters results in reductions in latent mortality leading to increased survival during later life-stage development in the estuary and marine environments.

Total Dissolved Gas

Spill at CRS dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Biological monitoring within the CRS shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 125% of saturation (Antcliffe et al. 2002; Backman et al. 2002; NMFS 2019). When those levels are exceeded, however, there is a corresponding increase in the incidence of signs of GBT symptoms. (McGrath et al. 2006) determined that new research supports previous research indicating that short-term exposure to up to 120 percent TDG does not produce significant effects on juvenile (or adult) salmonids when compensating water depths are available (Beeman and Maule 2006; NMFS 2019). Therefore, it is anticipated that any increase in TDG as a result of implementing the flex spill operation will result in negligible increases in GBT to outmigrating juvenile SR sockeye salmon through the CRS because the Proposed Action is not intended to exceed the 125 percent “gas cap” during periods of voluntary spill.

Temperature

Temperature influences growth and feeding rates, metabolism, development, migration timing, and the availability of food. In addition, temperature plays a role in predator fish behavior which also affects

juvenile salmonid survival. Adverse (high) water temperatures, however, can cause stress and mortality to SR sockeye salmon.

Current temperature conditions are different from historic ones as a result of a suite of anthropogenic activities (see status of the species section), but are generally not elevated sufficiently to be detrimental to SR sockeye salmon during the time juvenile sockeye are actively migrating downstream. Recent events and analyses suggest that sockeye could confront harmful water temperatures more frequently. The Proposed Action includes tailored releases of cold water from Dworshak to help mitigate the effects of increasing air and water temperatures. Because operations cannot further be changed to reduce temperatures, it is anticipated that temperature changes attributable to the Proposed Action are likely indistinguishable from current conditions and will result in negligible consequences to outmigrating juvenile SR sockeye salmon.

Turbidity

Development of the CRS (and other non-federal dams) has reduced sediment transport from historic levels and subsequently reduced turbidity by having suspended particles in the water fall out when the water enters a slower moving reservoir. This is part of the environmental baseline. Lowered turbidity levels may increase the susceptibility of SR sockeye salmon to avian and piscivorous predators due to increased visibility in the water column. Avian predation is most likely to occur in the tailrace of the dams, while piscivorous predation may occur in both the forebay and the tailrace. Implementing the Proposed Action is unlikely to result in changes in the amount of suspended solids (and resulting turbidity) in the water column through the CRS. However, while outmigrating juvenile SR sockeye salmon will continue to experience a less turbid system as a result of past actions, the Proposed Action does include measures to address predation impacts in the vicinity of the dams and in the estuary, as described next.

Predation

A variety of bird and fish predators consume juvenile SR sockeye salmon on their migration from tributary rearing areas to the ocean. Existing conditions create habitat that is more ideal for both native and non-native predatory fish than pre-CRS conditions. Outmigrating juvenile SR sockeye salmon encounter predatory fish during passage through reservoirs, dam forebays, and dam tailraces of the CRS.

Implementing operations of the Proposed Action will not substantially change environmental baseline conditions for the distribution and abundance of piscivorous fish in the CRS. Thus, while it is anticipated that outmigrating SR sockeye salmon will continue to experience predation exposure in the CRS, conditions under the Proposed Action are not expected to worsen. On one hand, fish in the dam tailraces that may be particularly susceptible to predation could benefit from the flex spill program through increased spill discharge, which would increase turbulence immediately downstream of the dams and make it more difficult for predators to locate and prey upon juvenile salmonids in these areas. On the other hand, increased spill discharge may increase disorientation of outmigrants in spillway tailwaters, leading to increased vulnerability to avian predation.

Juvenile sockeye salmon survival is expected to increase by up to 2% through the John Day Reservoir during the spring migration period as a result of deterring Caspian tern nesting at Blalock Island Complex

with increased reservoir elevations as defined by the proposed action (see Chapter 2) (Evans et al. 2019). Increased reservoir elevations are expected to decrease travel rates through the John Day reservoir. Decreased travel rates may increase vulnerability to predation by piscivorous fish.

Non-Operational Conservation Actions

Predation Management

Management efforts to reduce predation by birds and northern pikeminnow will continue with the Proposed Action. Collectively, these efforts are intended to continue to minimize predation rates on outmigrating juvenile SR sockeye salmon passing through the CRS.

Bird predation is a significant environmental baseline source of mortality for SR sockeye salmon (Evans et al. 2018). The Action Agencies have developed various plans to help minimize predation by birds. In 2014, the Inland Avian Predation Management Plan (IAPMP) began (Corps 2014a). This plan manages avian predation on juvenile salmonids as they migrate to the ocean by reducing bird nesting colonies in inland areas by installing a variety of passive nest dissuasion materials prior to nesting seasons (Evans et al. 2018). A Double-crested cormorant management plan for East Sand Island in the estuary was completed in 2015. And, avian dissuasion actions at the dams (e.g., wires, sprinklers, etc.) will continue with the Proposed Action.

Avian

Based on PIT-tag recoveries at East Sand Island in the lower estuary, average annual tern and cormorant predation rates for SR sockeye salmon were about 1.5 and 3.6 percent, respectively, before efforts to manage the size and nesting location of these colonies (Evans et al. 2018). Previous management actions implemented by the Action Agencies to relocate various tern colonies has had some positive effect by reducing the predation rate on SR sockeye salmon to 1.4 percent (Evans et al. 2018). Efforts to minimize predation by birds will continue with the Proposed Action.

The northern pikeminnow, a native fish, is a significant predator of juvenile salmonids in the Columbia River. In 1990, the Action Agencies began the NPMP to reduce predation on juvenile salmonids by northern pikeminnow through targeted removal of northern pikeminnow at mainstem CRS dams. In addition, a Pikeminnow Sport Reward Fishery program has been instituted that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake Rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. Incidental catch of ESA-listed salmon and steelhead as a result of implementing pikeminnow management programs has occurred in the past and is likely to continue at a similar rate in the future. While the numbers are low, some individuals are likely part of the SR sockeye salmon ESU.

Predator management programs will continue under the Proposed Action. They are anticipated continue to maintain benefits achieved to date for reducing consumption of juvenile salmon and steelhead by avian and fish predators. Specifically, continuing to implement the Caspian tern and Cormorant management plans and the NPMP will result in negligible changes in predation, but will prevent the impacts from “backsliding” to levels that were occurring prior to the Action Agencies implementation of these plans.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on SR sockeye salmon associated with the capturing and handling of fish. RM&E activities occur throughout the Columbia River Basin as part of managing the CRS. In general, the RM&E program is a collaborative, regionally coordinated effort for status and trend monitoring for habitat and fish, action effectiveness monitoring and research, critical uncertainty research, synthesis and evaluation, and data management. Capturing, handling, marking, tagging, and releasing fish is generally stressful and can have sublethal and sometimes lethal effects. Furthermore, some RM&E actions also involve euthanizing fish for research purposes. NMFS (2019) estimated the number of juvenile SR sockeye salmon that have been handled each year during the implementation of RM&E under the 2008 BiOp and determined that the average handling and mortality were not substantial. They concluded:

...slightly more than one percent of the wild juvenile production was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to one percent of these juveniles (in this case, <0.02 percent of the wild production) died after they were released due to effects of handling. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of FCRPS operations, including modifications to facilities, operations, and mitigation actions.

It is reasonable to assume that implementing the Proposed Action will result in the number of individual SR sockeye salmon handled, injured and/or killed from RM&E activities continuing in the future at approximately the same level as is currently the case.

Juvenile Sockeye Salmon Estuary Migration and Rearing, Including the Plume

Ecosystems in the estuary (defined as Bonneville Dam to the ocean) and Columbia River plume provide habitat for juvenile SR sockeye salmon to migrate in, forage, adapt physiologically, and, in some cases, avoid predators. The existence and operations of the CRS has led to long-standing changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, any direct impacts on these parameters due to the Proposed Action of continuing CRS management are expected to be minor.

The indicators used below to assess the effects of the Proposed Action on juvenile SR sockeye salmon migration through the estuary and plume are categorized as operational (survival, fish travel time, TDG, temperature, turbidity, and predation) and non-operational (predation management and fish status and trend monitoring). Using these indicators, analyses of effects to SR sockeye salmon during downstream migration through the CRS as a result of implementing the Proposed Action are described in the next sections.

Operational

Survival

Foraging and growth in the estuary improves fish condition and likely increases subsequent survival during early ocean residence. Monitoring and research data suggest that fish size and time of ocean entry, which are in part due to conditions in the estuary, can affect salmonid growth and survival in the ocean (Chittaro et al. 2018; Johnson et al. 2018). Habitat enhancements that increase access to rearing areas, improve habitat capacity (e.g., prey productivity), and increase prey export to the mainstem estuary likely lead to increased growth and improved condition of migrating juvenile SR sockeye salmon in the estuary.

Fish Travel Time

Changes in CRS water management in the Proposed Action are not expected to alter fish travel time through the estuary. Therefore, under the Proposed Action, travel time in the estuary of juvenile SR sockeye salmon is not likely to change from the baseline condition.

Total Dissolved Gas

Elevated TDG levels occur during periods of increased spill downstream are attenuated by approximately RM 110 in the estuary (NMFS 2019). Juvenile SR sockeye salmon exposed to increased TDG levels (120% to 125%) are likely to experience slight increases of GBT resulting from the Proposed Action as compared to the baseline condition.

Temperature

As mentioned above, during the time when juvenile SR sockeye salmon are outmigrating, the proposed operation of the CRS has limited capabilities to modify water temperatures in the mainstem Snake and Columbia Rivers. Therefore, water temperature changes due to the Proposed Action are not expected in the estuary and plume.

Turbidity

Implementing the Proposed Action is not likely to affect turbidity levels in the estuary and plume.

Predation Rates

The Proposed Action is not anticipated to have any effect on the rate of predation of juvenile salmonids in the Columbia River estuary and plume.

Non-Operational

Predation Management

The Proposed Action will continue to implement the various predator management programs that are currently being implemented in the estuary and mainstem Columbia River. Some ESA-listed fish are

captured as part of implementing the Pikeminnow Sport Reward Fishery and dam angling program. The number of individual sockeye impacted is likely to continue at a similar rate in the future. While the numbers are low across the entire program, some individuals below Bonneville Dam and in the estuary may be captured, injured, or killed.

Estuary Habitat Actions

As part of the Proposed Action, the Action Agencies will continue implementing CEERP to improve estuary floodplain habitats, including tidally influenced portions of tributaries, used by outmigrating salmon and steelhead. Project effectiveness is expected to increase over time as the restoring habitats mature and new, more effective restoration projects are implemented because program sponsors will be taking into account lessons learned from previous projects within CEERP's adaptive management framework (Diefenderfer et al. 2016).

Fish Status and Trend Monitoring

The RM&E component of CEERP includes actions to monitor status and trends of habitat and fish, perform action effectiveness monitoring and research, and conduct critical uncertainties research. CEERP is implemented using an adaptive management process to capture learning from RM&E and adjust accordingly program strategies and actions (Johnson et al. 2018). RM&E will continue under the Proposed Action. Capture and handling of juvenile salmon and steelhead, some of which are likely SR sockeye, may result in stress, injury, harm, and in extreme cases, death, will occur as part of RM&E in the estuary.

Ocean Rearing

CRS management has no *direct* influence on survival of SR sockeye salmon in the Pacific Ocean. There are, however, a small number of individual salmon and steelhead that could experience deleterious direct effects from capture and handling from a Bonneville-funded study of juvenile salmonid ecology in the plume and nearshore ocean. *Indirect* effects on survival of SR Sockeye salmon from CRS management include any latent/delayed mortality manifested in the ocean and the positive influence CRS management can have on juvenile migration and growth in the estuary, which is related to improved survival during early ocean entry.

The Proposed Action will have no effect on the ocean habitats used by SR sockeye salmon for growth and maturing because there are no CRS operations that affect this area (the Columbia River plume was addressed above).

Adult Sockeye Migration to Bonneville Dam

It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River by the distance from the facilities combined with streamflows from lower Columbia River tributaries like the Willamette River. The Proposed Action is unlikely to cause adult migration barriers for SR sockeye adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River

because local, regional, and annual climate and streamflow conditions, combined with lower Columbia River tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. Pinniped management actions at Bonneville Dam are expected to reduce this impact to some degree. Thus, overall, the Proposed Action is likely to have negligible effects on SR sockeye adult migration from the ocean to the CRS.

Further analysis of effects to adult SR sockeye salmon returning to the Columbia River and migrating up to Bonneville Dam as a result of implementing the Proposed Action is described next. The analysis is organized by operational and non-operational components.

Operational

Survival

The Proposed Action is not expected to negatively affect the migration corridor, and hence survival, for adult SR sockeye salmon in the estuary (Bonneville Dam to the ocean).

Fish Travel Time

The Proposed Action is not expected to negatively affect the migration rate of adult SR sockeye in the lower Columbia River downstream from Bonneville Dam. The Proposed Action will result in negligible flow reductions, and thus a minor reduction in water particle velocity at the time adult sockeye will be entering and migrating through the estuary.

Total Dissolved Gas

As a result of the flex spill operation during spring, early migrating adult SR sockeye will be exposed to slightly elevated TDG levels. Most adult SR sockeye, though, enter the Columbia River from the ocean in July and August after the flex spill program has concluded and, as such, will not be exposed to potentially elevated levels of TDG. Therefore, based on the attenuating effect on TDG of distance downstream of the CRS, the influence of tributary streamflow, and the timing of adult UCR steelhead migration to Bonneville Dam, the Proposed Action are not expected to adversely affect adult SR sockeye in the estuary during migration to Bonneville Dam.

Temperature

Effects of the Proposed Action are not expected to result in elevated water temperatures downstream from Bonneville Dam and, therefore, are not likely to negatively impact adult SR sockeye salmon within this reach.

Turbidity

Existence of the CRS has decreased sediment loads transported downstream by the Columbia River. In fact, it is estimated that the total sediment discharge into the estuary and the Columbia River plume is approximately one-third of pre-hydrosystem levels (NMFS 2019).

Effects of the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam and, therefore, are not likely to negatively impact adult SR sockeye salmon within this reach.

Non-Operational

Predation Management

For upstream migrating adult SR sockeye, the primary factor affecting survival to Bonneville Dam is pinniped predation. The existence of Bonneville Dam, which is part of the environmental baseline, likely causes pinnipeds to congregate downstream from that project. However, if Bonneville Dam were not present, the pinnipeds would likely congregate at Cascade Falls or other upstream falls, much like they do at Willamette Falls. Estimates of pinniped predation downstream of Bonneville Dam are not available for adult SR sockeye; however, salmonid consumption by California sea lions, Stellar sea lions and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). Wargo Rub et al. (2019), as cited in NMFS (2019), found 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 more than 500 in 2014 through 2017 [Wright et al. (2018) as cited in NMFS (2019)].

Measures intended to reduce the baseline effects of pinniped predation on adult salmonids such as hazing, removal, and the continued use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates) will continue under the Proposed Action. Furthermore, if pinnipeds are observed in the tailrace of The Dalles Dam, hazing efforts may be implemented at that project's ladder entrances. No components of the Proposed action are expected to result in a change from current conditions associated with pinniped predation.

It is anticipated that the Action Agencies will continue to implement the NPMP as well as the Sport Reward Fishery in the lower Columbia River estuary, and that sockeye, including some SR sockeye will be handled and/or killed during those activities. NMFS estimates that no more than 10 adults and 100 juveniles will be killed annually, which includes both SR sockeye and sockeye destined for the upper Columbia River (NMFS 2019). However, these activities are expected to maintain the 30 percent reduction in predation rates achieved under the 2008 RPA (NMFS 2019). These programs are a continuation of existing programs and are not part of the Proposed Action.

Adult Sockeye Migration Through CRS Dams

Snake River Basin sockeye migrate upstream through all eight Columbia and Snake River CRS projects on their way to spawning grounds. Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species since they have survived high-mortality life-stages such as marine residence and juvenile rearing, and are nearly at the point of spawning and giving rise to successive generations.

As reported earlier, after accounting for reported harvest rates and expected stray rates, adult SR sockeye have relatively high survival rates passing the lower Columbia and Snake River CRS dams. For

the years of 2008 to 2014, the average survival rate of adult SR sockeye in the Bonneville to McNary Dam reach was 71.9 percent. For the McNary to Lower Granite reach, survival averaged 89.2 percent. Overall for that time-series, survival from Bonneville Dam to Lower Granite Dam averaged 63.3 percent (Crozier et al. 2015). This estimate of minimum survival includes all sources of mortality, not just the effects of CRS operations.

An analysis of effects to adult SR sockeye salmon migrating upstream through the CRS as a result of implementing the Proposed Action follows. The analysis is organized by operational and non-operational components.

Operational

As discussed previously, the Proposed Action includes a flex spill program for spill at CRS projects to a level where the state water quality limit for TDG is met 16 hours per day and a performance spill component is implemented 8 hours per day. The flex spill program will occur April 3 through June 20 at the lower Snake River projects and April 10 through June 15 at the lower Columbia River projects.

The Proposed Action also includes modifying the Bonneville ladder serpentine weir to reduce delay within the fishway (this structural change is included under operational effects for convenience) and providing flexibility to decrease pool elevation in John Day Reservoir by 0.5 feet to increase water particle velocity and reduce fish travel time. Collectively, these measures along with the flex spill Program have the potential to impact SR sockeye salmon, as described next.

In the event high water temperatures are observed and emergency transport operations for adult Snake River sockeye are implemented, benefits are expected to be similar to those realized in 2015 (NMFS 2016c). The trap-and-haul operation allowed some of the Snake River sockeye salmon to complete their migration to the Sawtooth Valley and increased the number of spawners by an estimated 38 percent. This is an effective tool to improve the likelihood that Snake River sockeye salmon survive periods of extremely high water temperatures and results in an increase in the number of adults reaching their natal spawning lakes.

Fallback

The rate of fallback at CRS projects for adult SR sockeye for the period of 2008 to 2013 varied dramatically by year and project. Fallback ranged from 2.9 percent at McNary Dam in 2010 and 2012 to 38.1 percent at Lower Granite Dam in 2012. These fallback rates represent the number of unique fallback events by unique fish. However, when including multiple fallback events for individual fish, the fallback rate was as high as 49.2 percent at Lower Granite Dam in 2012 (Crozier et al. 2014). Based on the 6 years of data, the authors concluded that in 2013, there was a correlation between fish transported as juveniles and those that fell back as adults at Bonneville, The Dalles, and McNary Dams. However, they also observed that this relationship was weak or non-existent in the other years, and that fallback was strongly correlated with water temperature and/or flow (Crozier et al. 2014).

The Proposed Action, specifically the flex spill program, will have the potential to increase the rate of fallback at the four lower Columbia River CRS dams for the portion of fish that encounter the flex spill program. With increased spill, it is likely more of the fish that fallback at a given project will do so through the spillway, or some surface-oriented passage route. However, spill at lower Columbia River

dams will terminate on June 15. For fish that do fallback during the flex spill program, survival is expected to be relatively high. For later migrating fish, i.e., those that ascend the CRS after termination of the flex spill program, rate of fallback is not expected to change.

In sum, the Proposed Action has potential to negatively affect SR sockeye salmon by increasing fallback.

Total Dissolved Gas

SR sockeye enter the Columbia River estuary primarily in June and July and migrate upstream from Bonneville Dam in late June and July, with the median date of arrival ranging between June 29 and July 5 for the years 2008 through 2013 (Bjornn et al. 1968; Crozier et al. 2014). Since the flex spill program will occur April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects, most adult SR sockeye will not be exposed to elevated levels of TDG. However, earlier migrating adult SR sockeye will likely be exposed to elevated TDG levels.

As described in the previous section, GBT is not typically observed when TDG levels do not exceed 120 percent, and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Elevated TDG levels are only expected to be encountered below McNary Reservoir, and will be reduced as adults continue upstream past the confluence with the Snake River. Therefore, based on the limited observations of GBT at expected TDG levels associated with the Proposed Action and given the timing of adult SR sockeye within the CRS, the Proposed Action is not expected to result in an elevated risk of GBT to SR sockeye salmon.

Temperature

As described previously, poor water quality, which includes increased water temperature, can lead to stress in adult SR sockeye, which in turn can lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth and osmoregulation). Furthermore, elevated water temperatures can affect salmonid distribution, behavior, migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult SR sockeye (NMFS 2019).

Because actions associated with the Proposed Action will not result in elevated water temperatures within the CRS, effects of the Proposed Action are not expected to affect adult SR sockeye within this reach.

As discussed above, releasing cooler water from Dworshak Dam in the summer cools the mainstem Snake River, which decreases potential negative effects of increased water temperature on adult migration. Under the Proposed Action, reservoir operations at Dworshak will continue to cool temperatures in the lower Clearwater River and lower Snake River reservoirs during summer to improve environmental conditions for adult migrants. Cool-water releases from Dworshak Dam have substantially improved summer migrations conditions for adult sockeye salmon in the Snake River compared to operations before the mid-1990s (NMFS 2019).

Turbidity

Hydropower development in the Pacific Northwest has altered the extent of sediment transport downstream through the Columbia River, including within the CRS. While other anthropogenic activities

such as agriculture, irrigation, mining, logging, road building, etc. have increased sediment delivery to the mainstem Columbia River, both federal and non-federal projects act as sediment traps, decreasing sediment loads discharging downstream. These activities and baseline conditions are expected to continue at current rates.

Because actions associated with the Proposed Action are not expected to result in changes in baseline sediment load, the Proposed Action is not expected to affect adult SR sockeye salmon within the CRS.

Non-Operational

Predation Management

Predation on adult SR sockeye within the CRS is rare, with pinnipeds being the primary predator. While pinniped predation commonly occurs within the tailrace of Bonneville Dam downstream to the Pacific Ocean, pinniped observations upstream from Bonneville Dam are rare, with no observations above The Dalles Dam.

In addition, predator fish management programs, like the NPMP, could potentially effect SR sockeye as by-catch while the number of pikeminnow are being indexed through electroshocking. Based on past observations, NMFS is unable to estimate the number of SR sockeye that will be affected by this action. However, it is anticipated that the current level of take will continue for the duration of this Proposed Action (NMFS 2019). No components of the Proposed Action are expected to result in a change associated with this activity.

Adult Sockeye Migration Upstream of the CRS to the Spawning Areas

After migrating upstream through the CRS, adult SR sockeye continue up the Salmon River drainage to Redfish Lake where they will be collected at either the Redfish Lake Creek trap or the Sawtooth Hatchery weir. Once they enter the Salmon River, they are no longer directly exposed to the operation and related effects of the CRS.

Within the Snake and Salmon Rivers, which serve as migratory corridors for SR sockeye, a variety of limiting factors affect this ESU's ability to reach natal spawning areas and successfully reproduce. Processes such as climate change have contributed to altered water quality and quantity. In the Snake River upstream from Lower Granite Dam, limiting factors include altered flows, degraded riparian function, degraded water quality, and altered thermal regimes. Within the Salmon River, factors include degraded water quality (volume, temperature, and pollutants) and degraded riparian and in-stream habitat. In the Sawtooth Valley, access to natal lakes has been blocked or hindered, and increased sediment loads into those lakes has occurred due to historical land use, such as mining, sheep and cattle grazing, timber harvest, and road building in the watersheds surrounding the lakes. Also, flow has been reduced and migration blocked due to irrigation withdrawals and diversions (NMFS 2019).

Within SR sockeye tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies. A description of the effects of those actions follows.

Hatchery Programs

There is one sockeye hatchery program within the Snake River Basin. It is a safety-net captive broodstock program, where historically, both returning adult sockeye and captured juveniles were retained and raised in captivity until spawned. Currently, returning adult sockeye are used for broodstock, and of the SR sockeye collected annually for broodstock, approximately two-thirds are captured at the Redfish Lake Creek trap, and the remaining fish at the Sawtooth Hatchery weir.

Hatchery programs may provide short-term benefits such as increasing abundance, especially during periods of low natural abundance, and can also help preserve genetic integrity of a population until other limiting factors can be resolved. However, long-term implementation of hatchery programs can also negatively affect populations (NMFS 2019). This hatchery program is considered responsible for increasing the number of returning adult sockeye to the Snake River Basin (NMFS 2015).

The existing sockeye hatchery programs described above are expected to continue into the foreseeable future and are covered under a separate BiOp (USFWS 2018). The program will be implemented without alteration due to the Proposed Action. As such, existing effects will continue, but no new hatchery-related effects to SR sockeye are anticipated due to the Proposed Action.

Tributary Habitat Actions

For Snake River Basin sockeye, habitat degradation is the result of past and present anthropogenic activities. Much of the Redfish Lake watershed is classified as being in near natural condition. However, by 2007 approximately 25 percent of the lakeshore had been developed, with the shoreline being altered and the riparian vegetation removed. Also, the lake is regularly used as a recreational destination, with motorized and non-motorized pleasure and fishing boats, buildings, and hiking trails.

While no tributary habitat actions have been implemented specifically for SR sockeye, habitat actions within the Sawtooth Valley, or the Salmon River and its tributaries for other species indirectly benefits this ESU. Based on the best available science, NMFS has concluded that these actions have, and will continue to improve habitat for other species as these projects mature. Furthermore, fish population abundance, productivity, spatial structure, and diversity should respond positively (NMFS 2019) to improvements to the baseline conditions. The Proposed Action does not include tributary habitat actions specifically for SR sockeye; therefore, no direct effects to the ESU are anticipated with its implementation.

Fish Status and Trend Monitoring

It is anticipated that the Action Agencies' RM&E program will continue at current levels of effort, or perhaps at somewhat reduced levels. As such, the level of injury and mortality associated primarily with the capture, handling, and marking/tagging associated primarily with the capture and handling of SR sockeye is expected to be maintained at current levels.

Passage Emergency Operation

If a SR sockeye salmon passage emergency operation is declared, benefits are expected to be similar to those realized in 2015. Then, the trap-and-haul operation allowed sockeye to complete their migration to the Sawtooth Valley. It increased the number of spawners by about 38% and proved to be an effective tool to increase the likelihood of sockeye surviving this period of extreme temperatures

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Effects to critical habitat were assessed based on those elements of the Proposed Action that are likely to affect the physical and biological features (PBFs) essential for the conservation of the SR sockeye ESU. Effects to designated critical habitat include the Proposed Action and associated mitigation that affect habitat within spawning and rearing areas, the freshwater migration corridor, and estuarine areas.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of SR sockeye. Freshwater spawning and rearing areas occur upstream of the CRS so the effects of the Proposed Action are limited to tributary habitat mitigation actions which are intended to improve habitat function for SR salmon and steelhead (and indirectly for SR sockeye). For the tributary habitat program there will be some uncertainty about the actual locations, extent, and types of tributary habitat actions that will be implemented as part of the Proposed Action. However, anticipated effects of the tributary habitat improvement program are expected to include short-term impacts that will be mitigated through compliance with BiOp on Columbia River habitat improvements (NMFS 2013); long-term positive effects associated with the tributary habitat program are difficult to quantify, but are anticipated to benefit the species where they occur.

Freshwater Migration Corridors

Freshwater migration corridors are used by returning adult sockeye migrating upstream through the CRS and by juvenile sockeye migrating downstream. The existence of the eight lower Columbia River and Snake River dams and reservoirs, a condition of the baseline, has and will continue to affect the function of critical habitat within the mainstem Columbia and Snake Rivers by influencing passage and survival of juvenile and adult migrants. The Proposed Action includes ongoing actions to mitigate these baseline effects by improving the freshwater migratory PBFs through operation and maintenance of passage improvements and implementation of the predator management programs. These programs are collectively improving downstream survival and will continue to reduce the risk of predation on SR sockeye.

The Proposed Action also includes both structural and operational modifications to the CRS that may affect water quality and passage PBFs that SR sockeye must migrate through to complete their life cycle. However, the overall effects to these PBFs from implementing the Proposed Action are slightly positive with respect to passage conditions and risk of predation, and slightly negative relative to elevated TDG. The existence of the CRS is expected to continue to affect stream temperature, sediment, and turbidity and effects to these water quality PBF indicators are likely to remain unchanged as a result of the

Proposed Action. Passage conditions at each of the projects are anticipated to improve for both adult and juvenile sockeye as the flex spill program will provide more advantageous passage routes through spill bays at each of the projects for juveniles and increase survival of adult SR sockeye that fallback over spillways. Increasing the proportion of water discharged through the spill bays at each of the dams will reduce forebay residence time by providing a more pronounced surface-oriented flow path for juvenile sockeye, which it is hypothesized will reduce latent mortality.

Estuarine and Nearshore Marine Areas

Estuarine and nearshore marine areas have been designated as essential for the conservation of SR sockeye. The Columbia River estuary occurs far enough downstream from the CRS operations that any effects on water quality of the Proposed Action are attenuated as the distance increases downstream from Bonneville Dam and large tributary streams enter the Columbia River. Ongoing implementation of the Columbia River estuary habitat and predator removal or harassment programs are anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of the habitat program is likely to increase the capacity and quality of habitat in the Columbia River estuary while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal or harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to improve the safe passage feature of critical habitat.

The Proposed Action includes operational modifications to the CRS that may affect water quality downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions with a slight but potential increase in TDG associated with the flex spill program. The highest TDG levels (125%) are expected in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). For adult and juvenile salmon, an increase in TDG will potentially increase the incidence of GBT. Continued effects to the physical and biological features associated with stream temperature, sediment, and turbidity are anticipated downstream from the CRS but are likely to remain unchanged from the current condition as a result of the Proposed Action. Current passage habitat features will be unaffected for juvenile and adult SR sockeye as they migrate through the Columbia River estuary.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on SR sockeye in the context of environmental baseline and cumulative effects. Cumulative effects are effects of future state or private activities that are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past or are currently occurring, their effects are included in the baseline (whether they are federal, state, or private). To the extent non-federal activities are reasonably certain to occur in the future, their future effects are included in the cumulative effects analysis.

Most of the action, baseline, and cumulative effects identified in the analysis above are consistent with effects previously described for operation of the CRS in past consultations. In general, the Proposed

Action as a whole is not likely to limit species survival or critical habitat function. It carries forward a suite of beneficial actions that improve baseline conditions and offset negative effects attributable to the regulation of flows, including flow augmentation, fish passage operations, predation management, and habitat improvement. Though the Proposed Action does not cause substantial changes to current species conditions, there may be some modest site-specific effects from the continued operation of the CRS. It is also possible that increased spill levels, and associated adverse effects, will be offset by an increase in adult returns due to less powerhouse encounters as hypothesized by the CSS.

The summary below will follow the general structure of the analysis above and will discuss each factor that was previously evaluated.

Operational

Survival

Baseline survival of juvenile SR sockeye through the CRS is affected by the number of dams they pass, predators, travel time, and water quality. These factors are the result of multiple influences including construction and operation of the CRS. Survival has improved for juvenile SR sockeye migrating through the CRS to the ocean as a result of past and ongoing actions. Juvenile sockeye survival has also improved in the estuary and tributaries due to habitat improvements implemented by the Action Agencies. For adult SR sockeye, survival is affected in the estuary up to Bonneville Dam by pinniped predators.

Cumulative effects from future non-federal actions, and the effects of climate change and variable ocean conditions, have the potential to effect survival of SR sockeye. Land use activities (primarily non-federal) have the potential to affect juvenile survival by decreasing tributary and estuary habitat or degrading abiotic factors, such as stream temperatures from urban, rural, and agricultural development and runoff. Further degradation of nursery lake and tributary habitat could also affect adult SR sockeye survival by reducing holding and spawning areas, or development of passage barriers. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies implement fisheries that can have a direct effect on the number of returning sockeye to the SR tributaries (and in some cases, within the tributaries themselves).

It is anticipated that survival gains resulting from previous actions will continue and possibly increase as a result of continuing tributary and estuary habitat actions. It is also anticipated that past improvements to juvenile and adult passage conditions at the CRS dams will be maintained and several future improvements will be implemented under this proposed action. For downstream migrating juveniles, it is anticipated that not only will survival through the CRS improve, but ocean survival may increase as a result of fish entering the ocean with fewer powerhouse encounters during their downstream migration, should the latent mortality hypothesis be valid. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications to actions.

Fish Travel Time

The construction and operation of the CRS has slowed juvenile travel time compared to the pre-CRS condition, potentially increasing exposure to predators as juveniles migrate through the CRS. Travel time

within the tributaries and estuary is not affected by the existence or operation of the CRS. While travel time of SR sockeye juveniles within the CRS varies from year to year, actions from the past that are ongoing, send more fish through non-turbine routes, which is believed to decrease travel time and improve survival. Adult travel time is not considered an issue. However, increased water temperatures may lead to migrational delays at fishways which may reduce spawning success.

Future non-federal actions are not expected to affect travel time of juveniles or adults through the CRS during any life stage. However, it is anticipated that climate change will likely continue to increase overall temperatures in the Columbia River, and therefore have the potential to further affect adult SR sockeye upstream migrational timing, and possibly juvenile emigration timing.

The Proposed Action is anticipated to reduce forebay resident time for juvenile SR migrating past CRS projects during the flexible spill plan implementation. Continued monitoring of adult SR sockeye migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse Passage Proportion

Past and current physical modifications and operations of the CRS dams has increased the percentage of juvenile fish passing non-turbine routes. Decreasing powerhouse passage improves survival of juveniles during their downstream migration and migrating adults that may fallback (by falling back through the spillway rather than the powerhouse).

The effects from state and private actions are not anticipated to affect juvenile SR sockeye powerhouse passage.

The Proposed Action will continue implementing past improvements and actions that have resulted in increased non-turbine passage at the CRS projects. In addition, the Proposed Action will increase spill during the juvenile migration period and that is expected to result in fewer powerhouse encounters for juvenile SR sockeye during their downstream migration. Finally, as techniques and additional operations are considered, further increases in non-turbine passage could occur.

Total Dissolved Gas

Total dissolved gas has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Increased TDG to very high levels has resulted in GBT in juveniles and adults as they migrated through the CRS. Elevated TDG levels are not observed within tributaries or the estuary (where the effects of CRS operations on TDG are attenuated by distance and tributary inflow). The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

Continued monitoring of juveniles and adults for signs of GBT will inform managers on the effects of this action.

It is anticipated that implementing the flexible spill program will elevate TDG levels and may slightly increase the incidence of GBT in juvenile fish.

Temperature Changes

Water temperatures have been modified as a result of a range of anthropogenic activities, including construction and operation of the CRS, throughout the Columbia Basin. Increases in temperature can have a range of effects on both juvenile and adult SR sockeye.

On-going non-federal land management activities that affect temperature, such as agriculture and urban and rural development, and forestry, are not expected to change substantially during the period of this consultation. These activities, coupled with continued population growth in the region, will likely result in further degradations to the environment that influences water temperatures. However, small improvements may be realized from tributary actions that restore and preserve habitat, like riparian plantings.

Implementation of the habitat enhancement action component of the Proposed Action will continue to improve tributary temperatures but will continue to have minimal effect on mainstem temperatures.

Turbidity Levels

Currently, sediment loads in tributaries have been affected by historic land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and rearing habitat. In the mainstem Columbia and Snake Rivers, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk.

In the tributaries, non-federal actions such as urban, rural, and agricultural development are likely to continue to affect turbidity, however, improvements in tributary habitat for other ESUs/DPSs included in the Proposed Action are expected to result in reduced sediment inputs, resulting in modest, site specific improvements that will mitigate continued non-CRS activities that degrade habitat. In the CRS, the current condition is not anticipated to change, and no non-federal activities are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment levels in the tributaries. In the CRS, it is not anticipated that the Proposed Action will change the current condition.

Dam Passage (Adults)

Currently, SR sockeye migrate upstream through CRS projects on their way to natal spawning areas and experience a variety of factors affecting them, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish. Current adult passage conditions should improve with modifications at Bonneville and Lower Granite Dams fishways which should help reduce delay. Installation of pumping systems to provide cool water in adult fish ladders at Lower Monumental and Ice Harbor Dams should also improve adult passage conditions within the CRS. SR sockeye appear to survive their migration through the CRS at high levels and those survival rates are expected to continue with implementation of the Proposed Action.

Non-federal actions that have the potential to directly affect UCR spring-run Chinook adults migrating through the CRS are unlikely. However, the continued degradation of tributary habitat that increases

temperatures, and projected increased air temperatures due to climate change that will likely result in warming surface water temperatures indirectly influence migratory behavior in ways that slow or delay upstream migration and reduces survival and reproduction.

The Proposed Action will continue to monitor adult migration through the CRS and use that information to propose specific actions that will increase adult survival.

Non-Operational

Predation Management

Currently, both juvenile and adult SR sockeye encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinnipeds prey on adults as they enter the Columbia River from the ocean to the tailrace of Bonneville Dam, often leading to the mortality of a portion of returning adult SR sockeye. A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS, mostly in the tailraces of dams. This predation accounts for a portion of juvenile mortality during migration through the CRS.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS operation have no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

The Proposed Action will continue to implement the predator management programs to limit SR sockeye mortality from environmental baseline conditions. This should ensure that predation caused mortality does not increase, and may reduce overall predation rates. Some impacts to SR sockeye will occur as a result of implementing the northern pikeminnow predation program, but is considered minor.

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to operation of hydroelectric facilities, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin salmon and steelhead and their habitat depends on the design of hatchery programs, the condition of the habitat, and the status of the species, among other factors.

The majority of hatchery programs are run by the state in which they occur. It is anticipated that the current hatchery program will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue.

The Proposed Action only includes a single sockeye hatchery program within the Snake River Basin, which is a safety-net captive broodstock program. The existing SR sockeye hatchery program that is described previously is expected to continue into the foreseeable future and is covered under a separate BiOp (USFWS 2018). The program will be implemented without alteration due to the Proposed Action. Current hatchery programs will continue to be studied and management agencies will make recommendations to reduce potential effects.

Habitat Actions

Habitat conditions in the tributaries, mainstem Columbia River and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect SR sockeye include continued degradation of tributary habitat that increase temperatures, and projected increased air temperatures due to climate change that will likely warm surface water temperatures.

The Proposed Action will continue to rehabilitate the degraded baseline condition of habitat in the tributaries and estuary and thereby improve long-term survival for SR sockeye.

Fish status and trend monitoring

There are potential effects from CRS-related RM&E programs on SR sockeye. These are associated with the capturing and handling of fish. Research, monitoring, and evaluation activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no non-federal actions anticipated that would affect SR sockeye.

The proposed Action will continue to implement the RM&E programs that are currently occurring, with the potential to modify these programs in the future as the results of the monitoring programs are evaluated. While some individuals are harmed, even killed, as a result of RM&E activities, the actual numbers are relatively small, and the information gained outweighs these minor losses.

Summary

In

Table 3-10, the Proposed Action is compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action.

Most of the actions are anticipated to either have no effect, or a positive effect compared to the baseline condition (Table 3-10). This is partly because the Proposed Action continues numerous beneficial actions developed over the preceding decade, including habitat improvement, flow augmentation, and fish passage operations. Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-10. Summary comparison of the Proposed Action to current conditions for SR sockeye salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions for other ESU/DPSs in the tributaries could increase survival.
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
Fish status and trend monitoring	x	x	=		
Juvenile Sockeye Downstream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival.
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x		+	Continuation of predator management programs should decrease predation.
	Hatcheries	x		=	
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Juvenile Sockeye Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Predator management actions should reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Sockeye Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
Fish status and trend monitoring		x	=		
Adult Sockeye Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	May result in greater fallback rates, but survival of fallback events likely to improve
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Sockeye Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable
Fish status and trend monitoring		x	=		

3.1.2.3 Snake River Basin Steelhead DPS

This section examines the status of the SR steelhead, the status of SR steelhead critical habitat, and the effects of the Proposed Action on SRB steelhead.

STATUS OF THE SNAKE RIVER BASIN STEELHEAD DPS

The SR steelhead DPS was first listed under the ESA on August 18, 1997, at which time it was classified as threatened (62 FR 43937). That status was reaffirmed January 5, 2006 (71 FR 834), and then again on April 14, 2014 (79 FR 20802). Critical habitat for the SR steelhead DPS was designated on September 2, 2005 (70 FR 52630).

The status of a species is based on an assessment of extinction risk and is a function of abundance, productivity, spatial structure, and diversity. Those parameters are, in part, included in listing decisions, status reviews, and recovery plans. The most recent status review (NWFSC (Northwest Fisheries Science Center) 2015) used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis. However, in most cases, estimates of abundance are not available for the majority of SR steelhead populations due to challenges in conducting surveys throughout most of this DPS's range. As such, in their 2015 status review and the 2019 BiOp, NMFS used a set of metrics developed and recommended by ICTRT. While the material in the most recent status review and (NMFS 2019) are incorporated here by reference, the following provides a brief summary on the current status of SR steelhead.

The SR steelhead DPS includes all naturally spawned anadromous steelhead originating below natural and anthropogenic barriers in the Snake River Basin in southeastern Washington, northeastern Oregon, and Idaho (NMFS 2019). For this DPS, the ICTRT has identified a total of five extant MPGs that include a total of 24 populations throughout their range [ICTRT (2003) as cited in NWFSC (Northwest Fisheries Science Center) (2015)]. Those MPGs include the lower Snake River (2 populations), the Grande Ronde River (4 populations), the Imnaha River (1 population), the Clearwater River (5 populations), and the Salmon River (12 populations). (NMFS 2019) also identified several other potential historical populations that occurred upstream from Hells Canyon Dam (Powder River, Burnt River, and Weiser River). Since Hells Canyon Dam is a barrier to anadromous migration, those populations are now extirpated, as is the North Fork Clearwater population that was once part of the Clearwater River MPG. In addition to the naturally spawning populations, a total of five artificial production programs exists within the geographical range of SR steelhead and are included in this DPS (seven other steelhead hatchery programs are also operational but are not included in the DPS [NMFS (2019); Figure 1; Table 1]).

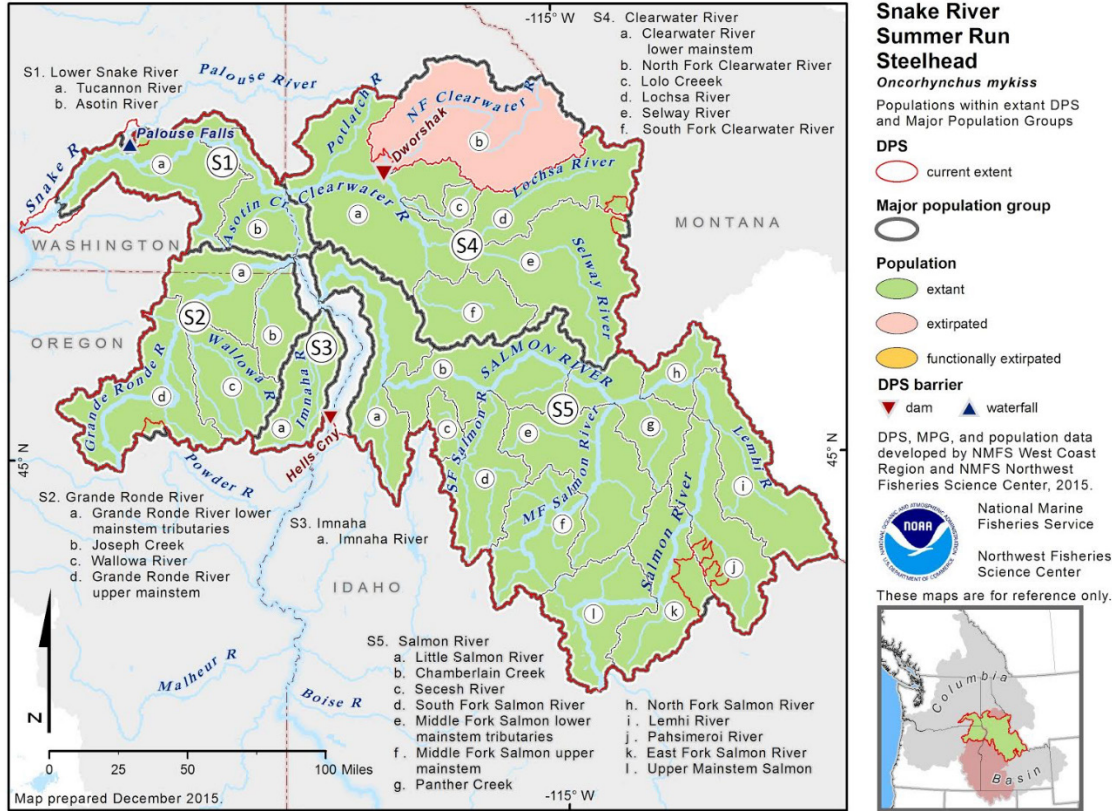


Figure 3-16. SR steelhead DPS spawning and rearing areas, illustrating populations, and major population groups [reproduced from NWFSC (Northwest Fisheries Science Center) (2015)]

Table 3-11. SR steelhead MPGs and populations and viability status (Jones 2015; NWFSC (Northwest Fisheries Science Center) 2015; NMFS 2019). Question marks in the viability rating column denote NMFS’s uncertainty in status of the population because of limited information.

Major Population Group	Populations	Status of Population (overall viability rating)
Natural Production		
Lower Snake River	Tucannon River	HIGH RISK??
	Asotin Creek	MAINTAINED? (HIGH RISK??)
Grande Ronde River	Lower Grande Ronde River	MAINTAINED?
	Joseph Creek	HIGHLY VIABLE
	Upper Grand Ronde River	VIABLE
	Wallowa River	Moderate?
Imnaha River	Imnaha River	Moderate?

Major Population Group	Populations	Status of Population (overall viability rating)
Clearwater River	Lower Main Clearwater River	MAINTAINED?
	South Fork Clearwater River	MAINTAINED/HIGH RISK?
	Lolo Creek	MAINTAINED?
	Selway River	MAINTAINED?
	Lochsa River	MAINTAINED?
Salmon River	Little Salmon River	MAINTAINED?
	South Fork Salmon River	MAINTAINED?
	Secesh River	MAINTAINED?
	Chamberlain Creek	MAINTAINED?
	Lower Middle Fork Salmon River	MAINTAINED?
	Upper Middle Fork Salmon River	MAINTAINED?
	Panther Creek	HIGH RISK?
	North Fork Salmon River	MAINTAINED?
	Pahsimeroi River	MAINTAINED?
	East Fork Salmon River	MAINTAINED?
	Upper Main Salmon River	MAINTAINED?
Artificial Production		
Hatchery Programs Included in DPS (n = 5)	Tucannon River summer, Little Sheep Creek summer, EF Salmon River Natural A, Dworshak NFH B, SF Clearwater (Clearwater Hatchery) B, Salmon River B	NA
Hatchery Programs Not Included in DPS (n = 7)	Lyons Ferry NFH summer, Wallowa Hatchery summer, Hells Canyon A, Pahsimeroi Hatchery A, Upper Salmon River A, Streamside Incubator Project A and B, Little Salmon River A	NA

Some key conclusions include (NMFS 2019)

1. For the Joseph Creek and the Upper Grande Ronde mainstem populations (both in the Grande Ronde MPG), where long-term data series of direct population estimates exist, both increased an average of 2 percent per year over the past 15 years.
2. Due to the lack of direct spawner abundance estimates for most populations, the status of most populations within this DPS remain highly uncertain.
3. Despite the level of uncertainty, NMFS concluded that for the 24 SR steelhead populations, the Overall Viability rating was Moderate for 2 populations, High for 3 populations, Maintained for 16 populations, Viable for 1 population, and High/Maintained for 2 populations (Table 3-11).

4. Updated information indicates that hatchery/spawner fractions are low due to relatively low straying of hatchery fish.

FACTORS AFFECTING THE STATUS OF SNAKE RIVER BASIN STEELHEAD

Within the Snake River tributaries that support the spawning and rearing of SR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, forestry practices, and development. Impacts associated with those activities include impaired tributary fish passage and degraded freshwater habitat, including reduced floodplain connectivity and function, degraded channel structure and complexity, reduced riparian areas and large woody debris recruitment, reduced streamflow, and reduced water quality (NMFS 2019).

Factors that occur during other life phases of the SR steelhead also have profound impacts on the status of the species and include genetic diversity effects from out-of-population hatchery releases, predation, adverse mainstem Columbia River hydropower-related effects, degraded ocean conditions, and harvest (NMFS 2019).

With a decline in salmonid production and, as a result, a decline in spawners within natal streams, nutrients vital to juvenile production have also decreased dramatically. Gresh et al. (2000) estimated that since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only about 6 to 7 percent of historical levels. They attributed this decline to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. These nutrients are important for salmonid production and, consequently, for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2002).

Over a total life cycle, the greatest incidence of mortality occurs where SR steelhead spend most of their life (i.e., tributary and ocean environments [see Section 3.2.1.1, Figure 3-1]). Tributary survival of juvenile steelhead varies depending on habitat and climate conditions, as well as the carrying capacity of the natal stream (Thurow 1987; Chapman et al. 1994). Quinn (2005), using average values from over 200 studies, found that egg-to-emigrant (smolt) survival for steelhead averages 1.4 percent.

Widener et al. (2019) compiled estimates of survival for juvenile steelhead migrating downstream through the Snake and Lower Columbia rivers. Survival estimates represented empirical estimates for specific geographic reaches, which, depending on the area of inference, could be from the forebay to the tailrace of a specific dam (dam passage survival) or from one dam (e.g., tailrace of McNary Dam) to another dam (e.g., tailrace of Bonneville Dam; reach survival). Widener et al. (2019) reported that survival from Lower Granite Dam to Bonneville Dam for natural-origin SR steelhead has averaged 0.43 from 1999 to 2018. Next, we discuss factors affecting the status of SR steelhead by life stage.

Freshwater Spawning, Rearing, and Migration to the CRS

SR steelhead use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. While many of the habitat degradations are relics of past anthropogenic practices, NMFS identified factors presently limiting viability in the SR in tributary areas that continue to influence

productivity. Factors limiting this DPS include (1) mainstem Columbia River and Snake River hydropower-related adverse effects; (2) impaired tributary fish passage; (3) degraded freshwater habitat, including degradation in floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, streamflow, and water quality as a result of cumulative impacts of agriculture, forestry, and development; (4) impaired water quality and increased water temperature; (5) related harvest effects, particularly for B-Index steelhead; (6) predation; and (7) genetic diversity effects from out-of-population hatchery releases (NMFS 2019).

The consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. As noted above (Section 3.2.1), the ISAB (2015) provided evidence for strong density dependence at current abundance levels for anadromous salmon and steelhead and suggests that habitat capacity has been greatly diminished. Density dependence was observed in most rivers where data have been examined, including in all 20 interior Columbia River Basin steelhead populations, despite natural spawners being much less abundant currently relative to historical abundance (ISAB 2015).

In an assessment of density dependence using a two-stage Gompertz model, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages. They concluded that, because of density dependence during the parr-to-adult stage, a greater number of fish reaching the ocean may not substantially increase the number of adults reaching the spawning grounds. Based on this evidence, the authors concluded the following:

This suggests that life cycle modeling to date has been overly optimistic about the benefits of survival rate increases in the hydrosystem and elsewhere to improve the viability of salmon populations threatened with high extinction risk.

While the modeling framework of Hinrichsen and Paulsen (2019) was applied to SR spring/summer Chinook, the results are consistent with the 2015 ISAB report, and therefore, it is reasonable to assume that SR steelhead are also experiencing similar effects of density dependency.

Past and present effects of the existence of CRS dams and past operations: SR steelhead are not exposed directly to the existence or operation of the CRS during adult holding, spawning, egg incubation, and juvenile rearing and initial migration within the tributary environment.

Past and present effects of hatcheries: Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They can also help preserve genetic resources until factors limiting natural productivity 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.

Existing hatchery programs are considered a threat for several SR steelhead populations. The situation is complex, however, because some of the populations may have become extirpated if not for the benefit of hatchery supplementation. Further, the existence of local hatchery stocks may help natural populations to bridge periods of adverse environmental conditions (as occurred in the 1990s). Nevertheless, large releases of hatchery fish can pose risks to natural-origin fish in the SR steelhead MPGs. For example, approximately four million B-Index steelhead are released into the Salmon River

and Clearwater River MPGs, primarily for harvest augmentation. These are large releases of hatchery fish relative to the likely size of natural production and pose ecological and genetic risks (e.g., spawning site competition and hatchery-influenced selection). Further, some of the non-local B-Index hatchery fish are released into areas where they are not the predominant life history type. Other potential problems include using out-of-MPG stocks and releasing fish without acclimation, which may increase the risk of straying (NMFS 2019).

(NMFS 2019) concluded that there are major uncertainties regarding the interactions and impacts of hatchery-origin steelhead on natural-origin fish.

These uncertainties include a limited understanding of the impact of hatchery releases on natural-origin population abundance, productivity, and genetic integrity, as well as the effects of ecological interactions between hatchery and natural-origin ESA-listed fish in the tributary, mainstem, estuary, and ocean environments. One of the main areas where information is lacking is regarding the relative proportion and distribution of hatchery-origin spawners in natural spawning areas at the population level, particularly for SRB steelhead (NWFSC (Northwest Fisheries Science Center) 2015).

Juvenile Steelhead Downstream Migration Through the CRS

As discussed previously, the Snake River Basin steelhead DPS consists of five MPGs, with four of those MPGs originating upstream from Lower Granite Dam. Populations within those MPGs migrate through eight CRS projects to and from the Pacific Ocean. The fifth MPG (lower Snake River MPG), consists of the Tucannon River and Asotin Creek populations. The Tucannon River enters the Snake River at RM 62, approximately 8 miles downstream from Little Goose Dam; therefore, this population migrates through a total of six CRS projects as juveniles and adults. Asotin Creek's confluence is approximately 37 miles upstream from Lower Granite Dam, and therefore, this population encounters all eight CRS dams.

Past and present effects of CRS existence and past operations: Through the CRS, juvenile SRB steelhead have been and continue to be exposed to the effects of both CRS operations and the existence of the CRS dams. Juvenile SR steelhead pass downstream of dams by many routes, including spillways and surface passage structures, intake screen bypass systems, and turbines. Major modifications have been made to projects within the CRS to improve survival and achieve the 2008 BiOp juvenile dam passage performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project (Table 3-3). Results from testing at the Columbia River CRS dams show that the juvenile passage performance standard is being met for juvenile steelhead (Table 3-12).

In addition, juvenile SR steelhead are transported to downstream of Bonneville Dam after being collected at Lower Granite, Little Goose, and Lower Monumental dams. Transportation of juvenile SR steelhead continues to show an overall benefit for SR steelhead. However, the degree of benefit has decreased as in-river survival has increased and the proportion of fish being transported has decreased subsequent to the increase in spill and the later transport collection dates that were implemented for juvenile yearling spring Chinook and steelhead in 2006.

Table 3-12. Average FPE and dam passage survival estimates for juvenile steelhead passing CRS dams [based on Table D-1 and D-2 from Bonneville et al. (2018a)]

Dam	Year of Studies	FPE	Year of Studies	Average Survival Estimate
Bonneville	NA	NA	2010, 2011	97
The Dalles	NA	NA	2010, 2011	97
John Day	2012	97	2011, 2012	98
McNary	2012, 2014	93	2012, 2014	98

Modifications include the installation of surface passage systems, improved turbine designs, and upgrades of screened bypass systems to improve how and where fish are returned to the river downstream from dams, as well as spill operations tailored to the unique structural configuration of each dam (Bonneville et al. 2017). A summary of those improvements is provided in Appendix A of Bonneville et al. (2018a) and is incorporated by reference here. Briefly, actions shown to have benefited UCR steelhead include the following:

- Minimize winter drafts of the large upper basin storage reservoirs (for flood risk management and power generation) to save water for augmenting spring flows during the peak juvenile passage period (water quantity).
- Employ JBSs and surface passage structures and provide spill at the run-of-river dams to divert smolts away from turbine units and reduce potential delay in the forebays and minimize predation (safe passage).
- Install replacement turbines with biologically based designs for safer fish passage than the case for the original units.
- Reduce TDG through multiple actions and plans.
- Manage avian and fish predators through multiple actions and plans.

For SR steelhead (hatchery and wild combined) cohort years 1997 to 2018, from McNary Dam to Bonneville Dam, reach survival rates averaged 0.68 (Widener et al. 2019). However, if these estimates are broken into specific time periods, the average reach survival estimate from McNary Dam to Bonneville Dam for years 1997 through 2008 (there were no estimates in 2004 and 2005 for this reach) was 0.57, while from 2009 through 2018, survival increases substantially to 0.79 (Widener et al. 2019). Comparing the reach from McNary to Bonneville Dam suggests that UCR and SR steelhead survive at very similar rates (Table 3-13).

Table 3-13. Comparison of survival of SR steelhead (wild and hatchery, and wild only) and UCR hatchery steelhead through the lower Columbia River System federal dams. Hydropower system survival estimates derived by combining empirical survival estimates, 1997–2018 [based on Tables 30 and 33 from Widener et al. (2019)].

Origin	Average Survival: McNary to Bonneville Dams
Snake River wild and hatchery	0.680
Upper Columbia hatchery	0.774

Because survival of fish passing the dams via non-turbine routes is higher than through turbines, passage facilities are designed and operated to increase the likelihood of juvenile fish passage through non-turbine routes. The metric by which this is measured is referred to as FPE. Depending on the location and time of year, greater than 90 percent of juvenile steelhead use these non-turbine routes at the four lower Columbia River dams [(Bonneville et al. 2017); Table 3-3].

As discussed previously, Widener et al. (2019) compiled estimates of survival for juvenile steelhead migrating downstream through the Snake and lower Columbia Rivers. However, those estimates included data for years preceding major physical and operational modifications to the CRS, and therefore, the estimates of survival do not fully express the benefits realized by those modifications. Following structural and operational modifications implemented after the 2008 BiOp, survivorship improved through the CRS [see above; (Corps et al. 2017a)].

In addition, TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can get forced into solution when water passes over the spillway at a mainstem dam, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019).

Past and present effects of predator management: Survival of Snake River juvenile steelhead is affected by avian and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple 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. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019). Specifically, predator management reduces predation by Caspian terns, which have a greater impact on steelhead than other salmonids, within mainstem Columbia and Snake River Reach through efforts at Potholes Reservoir and Crescent Island.

Juvenile Steelhead Estuary Migration and Rearing, Including the Plume

The estuary provides important habitat for SR steelhead populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has

reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also impacted estuary ecosystems. For a more detailed discussion of estuary and plume conditions, see (NMFS 2019). All these conditions are part of the environmental baseline.

Past and present effects of CRS existence and past operations: While there are no CRS facilities in the estuary (defined as Bonneville Dam to the ocean), the existence and past CRS management affected the timing and volume of flows, as well as temperature, sediment load, and TDG levels in this area. However, the influence of CRS dams and operations is generally attenuated below Longview, WA, due to distance from the dams, inflow from other tributaries joining the Columbia River, and multiple other dams and diversions within the basin that also affect flows and water quality in the estuary. The reduction in flows and associated sediment recruitment downstream from Bonneville Dam, which results from the existence of the dam, has likely limited some downstream habitat forming processes from being carried out.

Estuarine floodplain habitat is important for out-migrating juvenile salmon and steelhead, including SR steelhead. To help maintain and improve the overall status of salmon and steelhead in the Columbia River Basin, the Action Agencies actively work to restore and conserve habitat in the Columbia River estuary through CEERP. These restoration actions affect salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit of estuary restoration is that wetland food production supports foraging and growth within the wetland [Johnson et al. (2018) as cited in NMFS (2019)]. Prey items (primarily chironomid insects and corophiid amphipods; [PNL/NMFS (2018) as cited in NMFS (2019)] produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest 5-year review of the CEERP (Johnson et al. 2018), have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity below Bonneville Dam [Johnson et al. (2018) as cited in NMFS (2019)]. In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past and present effects of predation management: A variety of avian species (especially Caspian terns and double-crested cormorants) have historically been a major source of predation on juvenile salmonids in the estuary. While avian predators continue to prey upon juvenile salmonids, including SR steelhead, predation rates have declined due to a variety of management efforts. For example, between 2007 and 2010 (2003–2015 for cormorants), the average predation on SR steelhead by Caspian terns and double-crested cormorants from East Sand Island (near the mouth of the Columbia River) was approximately 22 percent and 9 percent, respectively (Evans et al. 2018). However, from 2011 to 2017, the average for Caspian terns dropped to 9.5 percent and 0 percent for double-crested cormorants (for years 2016–2017; (Evans et al. 2018). The efforts to reduce avian predation are discussed in detail within the 2019 BiOp and are incorporated by reference here (NMFS 2019). NMFS (2019) noted the success of implementing the avian management plans at meeting underlying goals; however, the results may be

uncertain at this time, because some cormorants and terns have relocated to other areas within the estuary. For example, although predation from cormorants on East Sand Island has significantly declined, the colony has respectively moved upriver to the Astoria-Meglar Bridge. Predation impacts on juvenile salmon from this re-located colony are unknown.

Ocean Rearing

The length of ocean residence for SR steelhead varies between A- and B-run fish, with A-run steelhead typically residing in the ocean for 1 year and B-run steelhead for 2 years (NMFS 2019). In the most recent adult return years since about 2014, poor ocean conditions have contributed to declines in ocean survival and associated adult returns. In the 2019 BiOp, NMFS provides a detailed discussion on ocean conditions, factors that affect the ocean environment, and impacts to SR steelhead; that information is incorporated here by reference. However, the following is a brief summary of those factors.

Factors that influence ocean conditions are also likely to affect survival of SR steelhead. The consequences of climate change will likely include increased water temperatures, more severe El Niño events, worsened ocean acidification, and major alterations in the northeast Pacific Ocean marine ecosystem associated with the Pacific Decadal Oscillation (NMFS 2019). These factors will affect SR steelhead survival either directly or indirectly because of their deleterious impacts on marine food webs.

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in distribution of aquatic marine organisms. Many species that typically occur in more southerly waters moved northward from southern California to Alaska in the unusually warm water during 2014 and 2015, which was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Pearcy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt marine ecosystems in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean and past CRS operations have had no direct effect on this DPS during ocean residence. Welch et al. (2018) concluded that marine survival of west coast Chinook and steelhead populations has collapsed over the last half century for most regions of the West Coast. Based on their review of annual survival estimates for Chinook and steelhead, they concluded the following:

We found that marine survival collapsed over the past half century by a factor of at least 4-5-fold to similar low levels (~1%) for most regions of the west coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Another factor that should be considered is delayed, or latent mortality. Delayed mortality is a term for harm caused when an animal survives one event or circumstance but incurs damage that only shows up later and may be expressed as illness or death. With Columbia Basin salmon and steelhead, the term is commonly applied in situations such as barging or dam passage of salmon or steelhead smolts. The term “latent mortality” is generally used more specifically to apply to the effects of dam passage. While most

or all of the fish might survive the act of barging or safely pass the dam, the delayed mortality hypothesis holds that a smolt is less healthy than it would be otherwise and therefore less likely to survive in the ocean and return as an adult.

The ISAB (2012) concluded, after reviewing various studies, that their analyses demonstrated that fish bypass systems are associated with some latent mortality, but the factors responsible for latent mortality remain poorly understood and are inadequately evaluated, further:

The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis).

Past and present effects of harvest: Harvest of steelhead in the ocean is rare (NMFS 2019).

Adult Steelhead Migration to Bonneville Dam

Adult steelhead migrating upstream after ocean residence typically do not feed within the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume and a migratory corridor free of obstructions to access spawning areas (NMFS 2019). Populations of SR steelhead enter the Columbia River estuary and pass over Bonneville Dam as early as June; most migrants are observed from July through the end of September, with peak migration in early- to mid-August (Keefer et al. 2016).

For upstream migrating SR steelhead, the primary factor affecting survival to Bonneville Dam is pinniped predation. Estimates of pinniped predation downstream of the Bonneville Dam tailrace are not available for adult steelhead from any DPS, although salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). The ODFW has documented an increase of monthly counts of California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, during the month of September. For the years of 2008 to 2014, the number of California sea lions observed averaged less than 500 animals; for 2015 and 2016, that average increased to more than 1,000 individuals (NMFS 2019).

The abundance of pinnipeds in the Bonneville Dam tailrace has increased over the course of the last 6 years (Tidwell et al. 2018). In a subsequent study, Tidwell et al. (2018) documented an average of 14.5 Stellar sea lions between July 21 and December 31, 2017, and on numerous occasions observed more than 20 individuals. Based on adjusted consumption rates, Tidwell et al. (2018) estimated a consumption rate of 1.54 percent for all steelhead, collectively, and concluded that the estimate is a reasonable rate of consumption on SR steelhead. Average pinniped impacts to summer migrating adult SR steelhead are likely relatively small, because pinniped counts are generally low in July and August (when most SR steelhead pass Bonneville Dam), and they are mixed with relatively abundant fall Chinook salmon migrating in September and October (NMFS 2019).

Past and present effects of CRS dams and past operations: There are no CRS dams that impede migration in the Columbia River estuary upstream to Bonneville Dam. As previously mentioned, adult SR steelhead enter the Columbia River from June through September, and the Action Agencies are required to spill

water over the CRS dams to increase survival of juvenile fish migrating downstream during a portion of that time. As such, adults may be exposed to higher levels of TDG, which may influence their migration behavior or increase their chances of GBT (NMFS 2019). TDG levels are mitigated, to some extent, downstream from Bonneville Dam due to gas dissipation and to mixing of water with lower TDG levels from tributaries such as the Willamette River.

Past and present effects of harvest: Harvest mortality in fisheries downstream of Bonneville Dam have been reduced substantially in response to evolving conservation concerns and restrictions for ESA-listed species. Historically, SR steelhead were harvested in both non-treaty commercial fisheries, as well as in recreational fisheries in the area downstream of Bonneville Dam to the mouth. In response to declining steelhead abundance, non-treaty commercial harvest of steelhead was prohibited in 1975, and treaty commercial harvest has been reduced and restricted to clipped (hatchery-origin) fish. As such, the harvest of non-clipped fish is incidental. Also, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986.

Adult Steelhead Migration Through CRS Dams

Most SR steelhead populations migrate upstream through all eight Lower Columbia and Snake River CRS projects on their way to natal spawning areas. During upstream migration, these fish experience a variety of factors, such as harvest, dam passage, straying, and pinniped predation. Moreover, temperature and flow conditions can increase the energetic demands of migrating fish [NMFS (2008b); Keefer et al. (2016) and Keefer and Caudill (2017) as cited in NMFS (2019)]. The primary factors influencing safe, timely, and effective adult upstream passage through CRS dams are tailrace flow dynamics, sufficient attraction flows to fish ladder entrances, operating ladders within criteria, reducing fallback, and maintaining safe ladder temperature and differentials (NMFS 2019).

Water is released from Dworshak Dam in the summer to reduce temperatures in the Snake River to reduce potential negative effects of increased water temperature on upstream migrating adult salmon and steelhead. Operators manage the Dworshak project so temperatures do not exceed 68°F at the tailrace of Lower Granite Dam. These releases substantially cool the lower Clearwater River and Lower Granite Reservoir. These ongoing cool-water releases have improved late summer migration conditions for adult SR steelhead in the Snake River (compared to historical conditions).

In addition, steelhead that survive spawning and try to return to the ocean (kelts) can be affected by the existence and operations of the CRS. CRS related mortality of downstream migrating kelts is not well known at this time. Colotelo et al. (2013) estimated that in 2012 40 and 45 percent of SR steelhead kelts survived from the Lower Granite forebay to the lower Columbia River (RM156) and the Bonneville dam face (RM 234), respectively, and 60 and 67 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 SRB kelts arriving at McNary Dam (less for SRB kelts entering the mainstem Columbia River in the John Day, The Dalles, or Bonneville Reservoirs) are lost upstream of Bonneville Dam (NMFS 2019).

Past and present effects of CRS existence and past operations: Under typical conditions, after accounting for reported harvest rates and expected stray rates, adult SR steelhead have relatively high conversion

rates,⁶ passing the Lower Columbia and Snake River CRS dams [six CRS projects for the Tucannon population (NMFS 2019)]. Survival for adult SRB steelhead from Bonneville to McNary dams averaged 94.3 percent over a 10-year period (range of 90.1 to 100.0 percent). This estimate of minimum survival accounts for all sources of mortality, including baseline, cumulative, and action effects, and can also be expressed as a survival rate of 98.1 percent per project (NMFS 2019). Based on the same dataset, the minimum survival estimate for the Bonneville to Lower Granite Dam reach has been estimated to be 86.6 percent (range of 81.2 to 94.1 percent). Based on this estimate of reach survival, per project survival averages 97.9 percent.

These estimates of minimum survival also account for impacts associated with fallback at the CRS projects, such as direct and indirect mortality associated with the fallback event, delay, straying, etc. The mean annual fallback rates at the lower Columbia River dams has been estimated to be about 6 to 9 percent and 3 to 6 percent at the lower Snake River dams [Keefer et al. (2016) as cited in NMFS (2019)]. Based on the relatively high survival estimates, (NMFS 2019) concluded that upstream passage conditions for adult SR steelhead are not substantially impaired as fish migrate through the Lower Columbia and Snake Rivers.

Past and present effects of predator management: As discussed previously, the presence of pinniped predators has increased within the Bonneville Dam tailrace in recent years, with occasional pinniped observations in the Bonneville Reservoir when SR steelhead are present [Tidwell et al. (2018) as cited in NMFS (2019)]. To restrict entry of pinnipeds into the ladder systems at Bonneville Dam, the Corps constructed structures to physically exclude pinniped entry into fishways, while allowing upstream migration of adult salmonids. These structures have been installed at all eight fishway entrances at Bonneville Dam (NMFS 2019).

Average pinniped impacts to summer migrating adult SR steelhead are likely relatively small, because pinniped counts are generally low in July and August (when most SR steelhead pass Bonneville Dam), and they are mixed with relatively abundant fall Chinook salmon migrating in September and October (NMFS 2019).

Past and present effects of harvest: Steelhead in the Columbia River are primarily harvested during what managers term the “fall season.” During the fall management period, fisheries target primarily harvestable hatchery- and natural-origin fall Chinook and coho salmon, and hatchery steelhead. Fall season fisheries are constrained by specific ESA-related harvest rate limits for listed SR fall-run Chinook salmon, and both A-Index and B-Index components of the listed UCR and SR steelhead DPSs.

A-Index and B-Index summer steelhead are caught in summer sport fisheries downstream of Bonneville Dam and, during fall through the following spring season, fisheries upstream. Non-treaty fisheries are subject to a 2 percent harvest rate limit for A-Index and B-Index summer steelhead in summer (from July 1 through July 31) and then from January 1 through the following spring. Non-treaty summer fisheries averaged a harvest rate of 0.7 percent on unclipped A-Index steelhead and 0.04 percent on

⁶ Conversion rates are simply the percentage of adult salmonids passing an upstream dam that passed a downstream dam ($\frac{\# \text{ passing}_{\text{upstream dam}}}{\# \text{ passing}_{\text{downstream dam}}}$). Conversion rate is used as a *surrogate* for survival rate. Factors other than mortality may affect the number of adult fish passing the upstream dam (e.g., tag not detected). Conversion rate can be interpreted as a minimum survival rate.

unclipped B-Index steelhead from 2008–2016 (NMFS 2018b). Non-treaty fall fisheries averaged a harvest rate of 1.9 percent on unclipped B-Index steelhead in the same frame. The yearly non-treaty harvest rate of unclipped A-Index steelhead in fisheries has averaged 1.9 percent and 2.0 percent for unclipped B-Index steelhead since 2008 (NMFS 2018b).

The treaty winter/spring harvest rate on unclipped A-Index steelhead during winter/spring fisheries averages 0.01 percent and 0 percent on unclipped B-Index steelhead. Summer fisheries have averaged 1.5 percent on unclipped A-Index steelhead and 2.4 percent on unclipped B-Index steelhead. The yearly treaty fall harvest rate of unclipped A-Index steelhead in fisheries has averaged 6.5 percent since 2008 and 17.9 percent on unclipped B-Index steelhead. From 2008–2016, the average treaty harvest rate on the unclipped portion of the B-Index steelhead stock was 20.2 percent (NMFS 2018b). Harvest rates are not expected to change over the course of the 2018 US v OR Agreement (NMFS 2018b).

Adult Steelhead Migration Upstream of the CRS to the Spawning Areas

Within the Snake River tributaries that support the spawning and rearing of SR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (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 streamflow during critical periods, (6) reduced floodplain connectivity and function, and (7) degraded riparian condition (NMFS 2019).

Low flows and high summer temperatures in tributary habitats can effectively create temporary migration barriers that reduce access to spawning habitat until conditions improve. These impacts to water quality in tributary habitat can affect the run timing and survival to natal spawning areas for adult UCR steelhead.

Past and present effects of harvest: Recreational fisheries for steelhead in SR tributaries and mainstem Columbia and Snake Rivers upstream of the CRS result in incidental impacts to natural-origin fish to an unknown degree. Of the fish that are caught and released, the assumption is that 10 percent will die from handling related injuries (NMFS 2019).

STATUS OF CRITICAL HABITAT

In this section, the status of critical habitat and factors affecting it are reviewed for SR steelhead. Critical habitat includes the stream channels within designated stream reaches and, to an extent, is defined by the ordinary high-water mark (33 CFR 319.11). The PBFs of critical habitat that are essential to the conservation of SR steelhead have been identified and include freshwater spawning, rearing and migration corridors, as well as estuarine and nearshore marine areas (Table 3-14; (NMFS 2019). The PBFs of critical habitat and climate change effects are presented in this section.

Critical habitat for the SR steelhead DPS was designated on September 2, 2005 (70 FR 52630). Critical habitat for SR steelhead was designated in the following watersheds (including major tributaries): Tucannon River, Asotin Creek, Joseph Creek, the mainstem of the Grande Ronde River, Wallowa River,

Imnaha River, lower mainstem Clearwater River, Lolo Creek, Lochsa River, Selway River, South Fork Clearwater River, Little Salmon, Rapid River, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Middle Fork Salmon River, North Fork Salmon River, Lemhi River, Pahsimeroi River, East Fork Salmon, and the mainstem Salmon River.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation role of critical habitat is to provide PBFs the support populations that can contribute to conservation of the DPS. More restoration is needed before the PBFs can fully support the conservation of SR steelhead.

Table 3-14. Physical and biological features and components and principal factors affecting the environmental baseline of critical habitat designated for SR steelhead [Based on NMFS (2019); Table 2.14-8].

PBFs	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
Freshwater spawning sites	Water quantity and quality conditions and substrate supporting spawning, incubation, and larval development	Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage) Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage) Diminished streamflow (degraded water quantity, elevated temperatures, loss of juvenile and adult mobility) Impaired fish passage (obstructions, water withdrawals) Excess fine sediment in spawning gravel (degraded water quantity) Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation)
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 supporting juvenile development 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	Impaired fish passage (obstructions, water withdrawals) Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage)

PBFs	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
Freshwater migration corridors	<p>Free of obstruction and excessive predation</p> <p>Adequate water quality and quantity</p> <p>Natural cover</p>	<p>Delay and mortality of adults (at up to eight mainstem dams)</p> <p>Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting)</p>
Estuarine areas	<p>Free of obstruction and excessive predation, with</p> <p>Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater</p> <p>Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels</p> <p>Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation</p>	<p>Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage) and the presence of toxic contaminants (reduced water quality and forage)</p>
Nearshore marine areas ^a	<p>Free of obstruction and excessive predation, with</p> <p>Water quality and quantity conditions and forage</p>	<p>Concerns about increased opportunities for pinniped predators and adequate forage</p>
Offshore marine areas	<p>Not designated</p>	

^a The designated nearshore marine area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

As discussed previously, SR steelhead enter the Columbia River estuary and pass over Bonneville Dam as early as June, but most migrants are observed from July through September, with peak migration in early- to mid-August (Keefer et al. 2016). Migration of SR steelhead through the CRS and areas upstream is complicated because of various environmental factors that affect migration. Returning adults of both A- and B-runs typically arrive above Lower Granite Dam by fall and hold in large tributary rivers for several months before migrating upstream into smaller tributaries to spawn. However, a small component of the runs (about 2 percent) will overwinter downstream from Lower Granite Dam and migrate upstream the following spring (NMFS 2019). During their freshwater migration, adult steelhead require cool water that is free of contaminants and migratory corridors with adequate passage conditions (water timing, quality, and quantity) to allow access to habitats required to complete their life cycle (NMFS 2019).

All steelhead spawn in gravel and cobble substrates that are largely free of fine sediments. Developing eggs require cool, clean, and well-oxygenated waters for proper development. Juvenile SR steelhead usually spend 2 years in freshwater but may remain longer depending on water temperature and growth. Juvenile migration to the ocean occurs during the spring freshet during the months of March through mid-June (NMFS 2019).

During their freshwater residence, juvenile salmonids need abundant food sources and instream cover to protect them from predators. Juvenile fish cover may include undercut banks, overhanging vegetation, logs and root wads, and large substrate (NMFS 2019). Off-channel habitat, side channels, and other low-stream velocity areas provide refuge during high-flow events. Cool waters offered by springs, seeps, and deep pools offer refuge when stream temperatures increase during the summer. Interstices offered by large substrate allow juveniles to seek refuge during the winter.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of SR steelhead. Spawning and rearing occurs in the following watersheds: Tucannon River, Asotin Creek, Joseph Creek, the Grande Ronde River, Wallowa River, Imnaha River, lower mainstem Clearwater River, Lolo Creek, Lochsa River, Selway River, South Fork Clearwater River, Little Salmon River, Rapid River, Chamberlain Creek, Secesh River, South Fork Salmon River, Panther Creek, Middle Fork Salmon River, North Fork Salmon River, Lemhi River, Pahsimeroi River, East Fork Salmon, and the mainstem Salmon River.

The quality of tributary habitat for SR steelhead varies substantially throughout the Snake River Basin. Some spawning and rearing habitat is in near-pristine condition, while other areas are minimally to highly degraded due to past human activities (NMFS 2019), including 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, timber harvest, mining, and urbanization [Lee et al. (1997) as cited in NMFS (2019)]. These factors include (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 streamflow during critical periods, (6) reduced floodplain connectivity and function, and (7) degraded riparian condition (NMFS 2019). Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel instability are common symptoms of ecosystem decline in areas of critical habitat. Lack of adequate summer streamflows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas of the interior Columbia River Basin. Large-scale habitat assessments in the interior Columbia River Basin indicate that in watersheds managed for natural resources extraction, the number of large pools has decreased substantially since the early 1900s, resulting in a significant decrease in habitat diversity [McIntosh et al. (1994) as cited in NMFS (2019)].

To address these issues and to mitigate impacts associated with the operation of the CRS, the Action Agencies, in cooperation with private, local, state, tribal, and federal entities, have implemented a variety of tributary habitat restoration actions throughout the Snake River region to benefit SR steelhead since 2007; those restoration actions are summarized in Table 3-15.

Table 3-15. Tributary habitat improvement metrics: SR steelhead, 2007–2015 [reproduced from NMFS (2019); Table 2.14-7]

Action Type ^a	Amount Completed
Acre-feet per year of water protected (by efficiency improvements and water purchase/lease projects)	58,854.3
Acres protected (by land purchases or conservation easements)	2,203.5
Acres treated (to improve riparian habitat, such as planting native vegetation or controlling noxious weeds)	6,210.3
Miles of enhanced or newly accessible habitat (by providing passage or removing barriers)	1,036.9
Miles of improved stream complexity (by adding wood or boulder structures or reconnecting existing habitat, such as side channels)	164.6
Miles protected (by land purchases or conservation easements)	179.3
Screens installed or addressed (for compliance with criteria or by elimination/consolidation of diversions)	69

^a Several of these categories (i.e., acres protected, acres treated, miles of enhanced stream complexity, and miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

In the 2019 BiOp, NMFS (2019) concluded:

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have 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 ISAB (2015) pointed out there is compelling evidence for strong density dependence at current abundance levels for anadromous salmonids and suggests that habitat capacity has been greatly diminished. The ISAB also suggests that changes in environmental conditions within habitats accessible to salmon and steelhead stemming from climate change, chemicals, and intensified land use appear to have further diminished habitat capacity. The ISAB (2015) found that density dependence was observed in all 20 interior CR steelhead populations during the 1980 to 2008 brood years.

The ISAB (2015) noted that studies of density dependence during the spawning and incubation stage are rare. In addition, other factors besides density dependence, such as sedimentation, streamflow, water temperatures, and winter freezing conditions, can be responsible for significant mortality during spawning and incubation. The ISAB (2015) concludes by stating that both the UCR and Snake River Basin steelhead DPSs show density-dependent interactions have a strong effect on recruitment of adults. And while few studies have examined the main cause of the observed density dependence (i.e., limitations in spawning versus rearing habitat) in steelhead, they suggest that the effect is most likely related to

interactions during rearing more so than during spawning stages and that further study is necessary to confirm this.

Key recommendations from the ISAB (2015) included the following: (1) account for density effects when planning and evaluating habitat restoration actions; (2) establish biological spawning escapement objectives that account for density dependence; (3) balance hatchery supplementation with the Columbia River Basin's capacity to support existing natural populations by considering density effects on the abundance and productivity of natural-origin salmon; and (4) improve capabilities to evaluate density dependent growth, dispersal, and survival by addressing primary data gaps.

Freshwater Migration Corridors

The freshwater migration corridor extends from the spawning and rearing areas in the Snake River subbasins downstream to the Columbia River plume. Migration corridors are considered essential to the conservation of SR steelhead. Human activities that have affected habitat in subbasin tributary reaches have already been discussed and contribute to the quality and quantity of water downstream and within the migration corridor of the Columbia River. Tributary habitat actions already implemented support all MPGs of SR steelhead and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, removing barriers to spawning and rearing habitat, and other actions targeted toward addressing limiting factors (NMFS 2019). No CRS projects exist in the freshwater tributary corridors, and SR steelhead are not exposed to any CRS operations until they reach the mainstem Snake River reservoir created by the first dam they encounter.

The quality of designated critical habitat within the mainstem Snake and Columbia River migration corridor is a function of the cumulative impacts of upstream actions, including impacts from development along the corridor, dam operations, and management within the CRS that affects both juvenile and adult SR steelhead. All these factors combine to affect critical habitat in the mainstem and influence the migration corridor. Habitat within the mainstem Lower Snake and Columbia Rivers has been substantially altered by a number of factors, including basin-wide water management, the existence and on-going operations of CRS hydroelectric projects, and other human-related activities that have degraded water quality and habitat (NMFS 2019). Within the 2019 BiOP, NMFS describes those factors affecting the behavior and survival of SR steelhead through the CRS, and that information is included here by reference (NMFS 2019). However, the following material briefly summarizes that information.

Mainstem dams and dam operations can affect stream temperature, streamflow, gas supersaturation levels, and river habitats. Both the Snake and Columbia Rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Because the temperature regime has been modified, resulting in warmer late-summer/fall water temperatures, it potentially affects juvenile and adult salmonids, as well as fish community structure. Warmer stream temperatures may influence predation rates on juvenile fish by predatory fish species. Juvenile fish may also be affected when water is spilled from hydroelectric facilities that increase gas supersaturation and may lead to GBT in fish. All projects create impoundments, which affect riverine habitats and can affect travel times, which in turn may increase juvenile fish exposure to both native and non-native predators. Some passage routes through dams may decrease juvenile fish survival (e.g., turbines) compared to spill bays and surface passage routes that are operated to increase

overall juvenile passage survival. The processes, general effects, and mitigation of CRS mainstem dams and dam operations on the functioning of critical habitat are shown in Table 3-16.

Table 3-16. The processes and effects of the CRS hydroprojects and mitigation efforts to address the effects

Process	Effect	Mitigation
Passage at hydro projects	Reduced juvenile survival at dams	Surface passage, increased proportion of spill, flow augmentation, TDG management, bypasses, and fish-friendly turbines
Water storage	Altered water quantity and seasonal timing	Flow augmentation
Solar radiation/reduction in mainstem stream velocity	Altered temperature, both in the reaches below the large mainstem storage projects and migration corridors	The dams result in water temperatures that are slightly better (cooler) during the spring migration
Water storage	Reduced sediment transport and turbidity in migration corridors and estuary	
Spill	Increased TDG	System-wide TDG management
Modification of habitat	Altered food webs, including both predators and prey	Avian management, fish bypass outfall placement (away from known predator concentrations), and pikeminnow removal (management)

In July–August, during the peak of the SR steelhead adult migration, solar radiation heats water in the surface layer of reservoirs. This heating can lead to increased water temperatures and temperature differentials in the fish ladders in the CRS and other hydro projects. Water temperatures within fish ladders exceeding 68°F and differentials (between water temperatures in the ladder and those of the tailrace) greater than 1.8°F have been demonstrated to cause delay in steelhead and can reduce their successful migration to natal tributaries (Caudill et al. 2013). Water temperatures within fish ladders commonly exceed 68°F and fish ladder differentials regularly exceed 1.8°F while SR steelhead are migrating [McCann (2018) as cited in NMFS (2019)]. During the most extreme summer days, water temperatures within fish ladders in CRS dams can exceed 75.0°F, and fish ladder temperature differentials can exceed 4.5°F [FPC (2019) as cited in NMFS (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 is ongoing to identify if cooler water is available and can be pumped into fish ladder exits.

Since 2008, when modifications to the physical and operational CRS system were first implemented based on the 2008 BiOp, survival of SR juvenile steelhead and adult migrants has improved substantially. For adult SR steelhead for the years of 2008 to 2017, the estimate of minimum survival for the Bonneville to McNary reach averaged 94.3 percent over the 10-year period (range of 90.1 to

100.0 percent). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 98.1 percent per project (NMFS 2019). Based on the same dataset, the minimum survival estimate for the Bonneville to Lower Granite Dam reach has been estimated to be 86.6 percent (range of 81.2 to 94.1 percent). Based on this estimate of reach survival, per project survival averages 97.9 percent.

Estuarine and Nearshore Ocean Areas

Critical habitat has been designated for SR steelhead in the Columbia River estuary (NMFS 2019). NMFS has defined the estuary to include the tidally influenced portion of the Columbia River (i.e., from Bonneville Dam (RM 146) to the mouth of the Columbia River), including the lower portions of tributaries influenced by tidal action. As such, the lower 26 miles of the Willamette River are also included within the estuary domain.

NMFS (2019) considers a functioning estuary essential to the conservation of UCR steelhead. NMFS identified the PBFs for UCR steelhead in the estuary to include areas free of obstruction with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater 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.

NMFS (2019) identified degraded habitat conditions in the estuary as a limiting factor for SR steelhead. Historically, the Columbia River estuary was more dynamic than it is today. Multiple channels, extensive wetlands, sandbars, and shallow areas, especially in the downstream 50 RM, were influenced by winter and spring floods, low flows in late summer, large woody debris, and high sediment loads NMFS (2019). As reported by NMFS (2019), the current conditions of the Columbia River estuary have changed as a result of many factors, including dredging to deepen and maintain the Federal Navigation Channel and construction of jetties and pile-dike fields to stabilize and concentrate river flow. Causeways have been constructed across waterways. As noted by NMFS (2019), the mouth of the Columbia River was historically about 4 miles wide but has decreased to about 2 miles wide, and the depth has increased at the Columbia River channel at the bar from less than 20 feet to more than 55 feet.

In particular, NMFS (2019) reported a dramatic decrease in wetland areas in the Columbia River estuary. More than 50 percent of the marshes and spruce swamps have been converted to industrial, transportation, recreational, agricultural, or urban areas, with more than 3,000 acres converted since 1948 (NMFS 2019). In the upper reaches of the estuary, many wetlands on the floodplain have been converted to industrial and agricultural lands after levees and dikes were constructed. As reported by NMFS (2019), 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost since the late 1800s. Those wetlands support salmonid food webs both in shallow water and in the mainstem.

Changes in streamflow and sediment delivery have also affected critical habitat in the Columbia River estuary. NMFS reports that water storage and release patterns from reservoirs upstream have changed the seasonal pattern and volume of discharge within the Columbia River estuary (NMFS 2019). Discharge has increased in the winter, and peak spring/summer floods have been reduced. NMFS (2019) also reported that model studies indicate combined human activities in the Columbia River Basin have

decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine-sediment transport by 50 percent or more. The significance of changes in sediment delivery to UCR steelhead is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean and subyearlings that may spend months in the estuary [Johnson et al. (2018); PNNL/NMFS (2018); and Weitkamp (2018) as cited in NMFS (2019)].

In terms of critical habitat, there are no CRS-related barriers to migration in the estuary, and there is no evidence that flows are insufficient for migration.

PROPOSED ACTION COMPONENTS SPECIFIC TO SNAKE RIVER BASIN STEELHEAD

The Proposed Action, continuing to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2 of this document and associated appendices, as modified by the flex spill Letter to NOAA. Reclamation is also consulting on the Columbia River mainstem effects of six irrigation projects that also have additional and separate ESA review⁷. The Proposed Action continues extensive operations that benefit SR steelhead, including flow augmentation, spill, surface passage, intake screen bypasses, and adult ladder operations. In addition, mitigation activities that have been implemented as part of previous BiOps will continue, including tributary and estuary habitat improvements; fish, avian, and pinniped predator management; and hatcheries for conservation and safety-nets (see Chapter 2). The Action Agencies will continue to coordinate with regional sovereigns and will regularly update plans for water management, fish passage, fish operations, and water quality. The Action Agencies intend to implement these actions commencing in September 2020.

SR steelhead are exposed to the CRS management as follows:

- Streamflow quantity and TDG changes from the Clearwater River confluence with the Snake River and from the confluence of the Snake River with the Columbia River and to the ocean.
- Passage through one to four CRS dams in both the downstream and upstream migrations.

Mitigation that is part of the action includes: flow augmentation; spill regimes at eight dams; cool water releases from Dworshak Reservoir during the summer migration period; juvenile fish transportation; fish facility operations at eight dams (bypasses, ladders, surface structures, outfalls, etc.); fish-friendly turbines at John Day, McNary, and Ice Harbor Dams; avian, fish, and pinniped predator management; tributary habitat actions linked to all SR steelhead MPGs; and estuary habitat actions.

⁷ Columbia River mainstem effects of certain Reclamation irrigation projects are included in this CRS consultation because the Columbia River hydrologic modeling incorporates all such impacts. The mainstem Columbia River impacts are included for the Yakima, Umatilla, Deschutes, and Crooked River irrigation projects. Snake River steelhead do spawn and rear in these tributaries. The flow impacts of these projects to the mainstem Columbia River are fully integrated in discussions of flow and TDG in the parts of the migratory corridor both used by this DPS and impacted by these projects.

EFFECTS OF THE ACTION ON SNAKE RIVER BASIN STEELHEAD

The effects of the existence of the dam and reservoir system and past operations are part of the baseline; they are not considered effects of the Proposed Action. The overall effects on SR steelhead of continuing to operate and maintain the CRS are related to downstream and upstream passage through the CRS mainstem Snake and Columbia River dams. This includes any potential latent/delayed mortality that may occur as a result of juvenile salmon passage at the dams. Improving juvenile and adult migration survival has been the focus of mitigation actions under past BiOps, and the benefits of these actions have been thoroughly documented (Corps et al. 2017a; Bonneville et al. 2018b). These already-completed actions will continue to provide benefits in the future. The effects of the Proposed Action on this DPS and its critical habitat are described by life stage below.

Freshwater Spawning, Rearing, and Migration to the CRS

In their spawning and rearing areas, SR steelhead are not exposed to the effects of operation of the Proposed Action, because no operations (e.g., flood risk management, irrigation, power generation) occur in these areas. Because of this lack of exposure, there will be no direct effects from CRS management to individual fish in these areas.

Some individual fish of this DPS are exposed to habitat improvements through the Tributary Habitat Improvement Program component of the Proposed Action. SR steelhead will benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that will result from the tributary habitat actions. Adverse effects to individuals from construction of habitat improvement actions are mitigated through compliance with BiOps for Tributary Habitat Improvement Program (NMFS 2013; USFWS 2013). The tributary habitat improvements are proposed for the Snake River tributaries that support major population groups. Activities in freshwater spawning, rearing, and migration habitats include work to improve streamflow protection and enhancement, habitat access, stream complexity, riparian habitat, screening to reduce entrainment, and more. These actions will continue to improve habitat condition over the baseline condition.

Juvenile SR Steelhead Downstream Migration Through the CRS

Juvenile SR steelhead are exposed to the effects of CRS operations once they reach the mainstem Snake River and as they pass through CRS dams. In this migration corridor, juvenile SR steelhead will continue to experience the deleterious impacts of a degraded environmental baseline and associated cumulative effects.

Through previous actions, operations and structures at individual CRS mainstem dams have been modified and adapted for the specific conditions of each dam to reduce turbine passage, decrease forebay and tailrace residence times, and improve overall dam passage survival (Corps et al. 2017a).

In general, the Proposed Action will continue operations and implement actions to minimize negative effects from both baseline conditions and the Proposed Action. Measures presently being implemented and proposed to continue include flow augmentation, measures to direct juveniles away from turbines (e.g., voluntary spill, surface passage structures, and intake bypass systems), fish-friendly turbines, and predator management.

Changes included in the Proposed Action compared to past operations include a flex spill operation and a new summer spill operation. Because juvenile UCR steelhead do not migrate during the summer, any changes in summer spill will not affect this DPS. Changes as a result of flex spill during spring are intended to increase juvenile passage survival for SR steelhead passing downstream through the CRS and decrease any potential latent/delayed mortality.

The indicators (also termed factors) used below to assess the effects of the Proposed Action on juvenile SR steelhead migration through the CRS are categorized as operational (modeling metrics, survival at CRS dams, mainstem CR fish travel time, powerhouse passage proportion, TDG, temperature, turbidity, and predation) and non-operational (predation management and fish status and trend monitoring). Using these indicators, analyses of effects to UCR steelhead during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Modeling Results

The EIS COMPASS and CSS modeling results generally support the qualitative expectations that survival rates through the CRS will increase for both the multiple objective alternatives 1 and 4 (MO1 and MO4) relative to the baseline condition (2016 No Action Alternative [NAA]). The exception to this observation is a slight decrease in juvenile survival for the preferred alternative based on COMPASS modeling (a decrease of 1.2 percent). For the same parameters, the CSS model predicts an increase in juvenile survival of 3.0 percent. However, estimates of survival for the MO4 alternative relative to the current conditions from the two models are more variable. Based on COMPASS modeling, survival is expected to increase by 0.9 percent relative to the current conditions; whereas, CSS predicts an increase in survival of 29.1 percent (Table 3-17).

Both models predict little or no change in juvenile travel time for the preferred alternative relative to current conditions. Based on COMPASS modeling, travel time is not expected to change for the two alternatives, with an anticipated travel time of 16.4 days through the CRS. For the CSS model, implementation of the preferred alternative is expected to increase juvenile travel time by 0.1 days (an increase of 0.62 percent). For the current conditions and MO4 alternatives, COMPASS predicts travel time will decrease by 1.3 days (-7.9 percent), and CSS predicts travel time will decrease by 1.6 days (-9.9%) (Table 3-17).

The most notable changes are expected to occur for powerhouse encounter rates, the proportion of fish transported, and TDG exposure during migration. Both models predict a reduction in powerhouse encounters of approximately 15–16 percent for the preferred alternative compared to the current conditions and about 80–86 percent for the MO4 alternative. While the two models evaluate transportation differently, both predict a significant decrease in transportation benefits for the MO4 alternative relative to the current conditions.

Table 3-17. Juvenile model metrics for Snake River Basin steelhead

Metric (Model)	NAA (2016 Ops)	Preferred Alternative		MO4		Range
		Value	Change from NAA	Value	Change from NAA	
Juvenile Survival (COMPASS)	42.7%	42.2%	-1.2%	43.1%	0.9%	0.9%
Juvenile Survival (CSS)	57.1%	58.8%	3.0%	73.7%	29.1%	16.6%
Juvenile Travel Time (COMPASS)	16.4 days	16.4 days	0.0%	15.1 days	-7.9%	1.3 days
Juvenile Travel Time (CSS)	16.2 days	16.3 days	0.6%	14.6 days	-9.9%	1.7 days
Transported (COMPASS)	39.7%	39.1%	-1.5%	7.2%	-81.9%	32.5%
Transported (CSS)	Unknown					
Transport: In River Benefit Ratio (CSS)	1.41	1.08	-23.4%	0.79	-44.0%	0.62
Powerhouse Passages (COMPASS)	1.73	1.47	-15.0%	0.35	-79.8%	1.38
Powerhouse Passages (CSS)	1.96	1.64	-16.3%	0.28	-85.7%	1.68
TDG Average Exposure (TDG Tool)	114.7%	115.1%	0.4%	119.8%	4.5%	5.1%
TDG-related Juvenile Survival	94.9%	94.4%	-0.5%	76.8%	-19.1%	18.1%

Survival at CRS Dams

Survival of SR steelhead juveniles once they enter the mainstem Snake and Columbia Rivers is influenced by a suite of factors—passage conditions at mainstem dams, flow conditions, water quality (e.g., temperature, TDG), predators, etc. Survival studies show, with few exceptions, that measures implemented through the previous CRS BiOps, and continued into the current Proposed Action, have performed as desired, achieving or very close to achieving the 2008 BiOp juvenile dam passage survival objective of 96 percent for juvenile steelhead (NMFS 2017e). For example, for juvenile steelhead (no

stock-specific estimates are available), dam passage survival has ranged from 96.5 percent to 97.6 percent at Bonneville Dam, 95.3–99.5 percent at The Dalles, 97.4–98.7 percent at John Day, and 96.9–99.1 percent at McNary (Bonneville et al. 2017).

While turbine survival is generally lower than spillway survival, survival for surface passage and intake bypass routes can be close to, equal to, or often greater than spillway survival in terms of direct dam survival. We anticipate that increases in spillway passage associated with spring flexible spill may result in increased reach survival.

It is important to note that since higher spill levels result in unbalanced energy and 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; however, most predictions are for increased survival.

As reported earlier (Table 2), average annual reach survival of natural- and hatchery-origin steelhead from the Snake River from McNary Dam to Bonneville Dam (235 km) increased from 0.57 (1997–2008; no estimates for this reach in 2004 and 2005) to 0.79 (2009–2018) (Widener et al. 2019).

Transportation

Recent transport rates (2008 to 2017) have averaged about 34 and 32 percent for wild and hatchery SR steelhead, respectively, and ranged from about 12 to 14 percent in 2015, up to 47 to 51 percent in 2008. These estimates represent a substantial reduction from the 1990s and early 2000s, when transport rates generally ranged from 70 to 99 percent (Widener et al. 2018). This reduction was due to both increased spill levels (24 hours each day) and a later (May 1) transport start date at the three Snake River collector projects. Estimated transport rates in 2018 were 47.5 and 46.4 percent for wild and hatchery steelhead smolts, respectively (Zabel 2018). This increase was primarily due to implementation of an earlier (April 24) transport start date that corresponded with an early outmigration and higher collection efficiencies resulting from high flow conditions in the lower Snake River.

In the event an emergency operation to collect and transport adult Snake River sockeye salmon is implemented due to high water temperatures at the Snake River projects, it is possible that juvenile Snake River steelhead may be harmed, injured, or even killed during the process of collecting and sorting adult sockeye salmon. However, it is very unlikely to this would occur, with the number of individuals injured or killed expected to be very low. During a Snake River sockeye salmon passage emergency, impacts are likely similar to those estimated in 2015, with less than 50 exposed to possible injury per day from mid-July to early August (NMFS 2015).

Mainstem CR Fish Travel Time

Under the flex spill plan, spring operations at the eight mainstem CRS dams will include spilling to state water quality limits (anticipate 125 percent starting in 2020) for 16 hours per day and to performance spill operations for 8 hours per day. Patterns and amounts for the performance spill operation were developed using a combination of prescribed spill and performance standard testing guidelines from the 2008 FCRPS BiOp and gas cap spill that uses spill up to state water quality standards, with some restrictions for erosion concerns and powerhouse minimums. The main effects of increased spill discharge will be a decrease in forebay delay and an increase in spill passage efficiency, with a reduction in hypothesized latent/delayed mortality (NMFS 2019).

Modeling results for SR steelhead estimates that the fish travel time will be slightly reduced. Additional flow through the spillways will likely draw a greater proportion of juvenile steelhead migrants from the powerhouse routes (turbines, intake screen bypasses, and sluiceways). Implementation of the Proposed Action could reduce juvenile travel time by approximately 8–10 percent. Decreasing smolt travel time with higher levels of spill through the CRS can provide a survival advantage because of reducing exposure time to predators and fostering a more normative synchrony between the physiological process of smolt transformation and the timing of seawater entry.

Under the Proposed Action, juvenile fish transportation would be suspended June 14 through August 15, then reinitiated and continued through November 15. Terminating transportation in mid-June may affect the tail end of the Snake River Basin steelhead outmigration. However, given the few fish still migrating downstream at the time transportation is terminated, this action is unlikely to impact SR steelhead to any significant degree. The re-initiation of juvenile fish transportation after mid-August would follow the SR steelhead outmigration and is not anticipated to affect this DPS. Furthermore, the higher spill under MO4 would substantially decrease the proportion of smolts transported during the spring spill season, because fewer fish would be passing through the juvenile fish bypasses (a higher proportion would pass via spillways) and, thus, not be available for collection and transport. The life cycle implications of these juvenile experiences are discussed further in the adult survival section.

Powerhouse Passage Proportion

In addition to increasing spill in the spring, the Action Agencies propose to modify the spillway surface passage weirs at John Day and McNary dams and install biologically based and designed turbines at Ice harbor, John Day, and McNary dams. These actions are anticipated to increase survival of juvenile fish that pass through those routes. Also, increasing the proportion of water discharged as spill directs a higher fraction of migrants away from the powerhouse and toward the less hazardous spillway. This reduces smolt encounters with turbines and screened bypass systems, both of which have been implicated in contributing to latent mortality as expressed in the marine environment. It is also possible that reduction in powerhouse encounters results in reductions in latent/delayed mortality, leading to increased survival during later life stage development in the estuary and marine environments. Both models predict a decrease in powerhouse encounters (80 percent COMPASS; 86 percent CSS), which could benefit Snake River Basin steelhead.

Total Dissolved Gas

Spill at CRS dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. This may occur during periods of high flows when involuntary spill is necessary or during set periods of time when water is spilled purposefully to implement the Proposed Action. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, which can result in injury or death. Survival of juvenile salmonids can decrease when TDG levels exceed lethal limits and fish are not able to compensate by swimming into deeper water (Beeman and Maule 2006).

Biological monitoring within the CRS shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 125 percent of saturation (Antcliffe et al. 2002; Backman et al. 2002; NMFS 2019). When those levels are exceeded, however, there is a corresponding increase in the incidence of signs of GBT

symptoms. McGrath et al. (2006) determined that new research supports previous research indicating that short-term exposure to up to 120 percent TDG does not produce significant effects on juvenile (or adult) salmonids when compensating water depths are available (Beeman and Maule 2006; NMFS 2019). Therefore, it is anticipated that any increase in TDG as a result of implementing the flex spill operation will result in negligible increases in GBT to outmigrating juvenile SR steelhead through the CRS, because the Proposed Action is not intended to exceed the 125 percent “gas cap” during periods of voluntary spill.

Temperature

Temperature influences growth and feeding rates, metabolism, development, migration timing, and the availability of food. In addition, temperature plays a role in predator fish behavior, which also affects juvenile salmonid survival. Adverse (high) water temperatures, however, can cause stress and mortality to SR steelhead.

Current temperature conditions are different from historical conditions as a result of a suite of anthropogenic activities (see the status of the species section). Generally, though, water temperature is not sufficiently elevated to be detrimental to SR steelhead when they are actively migrating downstream in spring through the CRS. During this time, the Proposed Action is not anticipated to change the current temperature regime in the Columbia River. Therefore, it is expected that temperature changes attributable to the Proposed Action are likely indistinguishable from current conditions and will result in negligible effect to outmigrating juvenile SR steelhead.

Turbidity

The existence of the CRS (and non-federal dams) has decreased sediment transport downstream in the Columbia River Basin, as suspended particles tend to settle out when sediment-laden water enters a reservoir, thereby reducing turbidity. These conditions are part of the environmental baseline. Lowered turbidity levels may increase the susceptibility of SR steelhead to avian and piscivorous predators because of increased visibility in the water column.

Implementing the Proposed Action is unlikely to result in changes to the amount of suspended sediment (and resulting turbidity) in the water column through the CRS. However, while outmigrating juvenile SR steelhead will continue to experience a less turbid system as a result of past actions, the Proposed Action does include measures to address predation impacts in the vicinity of the dams and in the estuary, as described next.

Predation

A variety of bird and fish predators consume juvenile SR steelhead on their migration from tributary rearing areas to the ocean (see Section 3.2.1.4). Existing conditions create a habitat that is more ideal for both native and non-native predatory fish than pre-CRS conditions. Outmigrating juvenile SR steelhead encounter predatory fish during passage through reservoirs, dam forebays, and dam tailraces of the CRS.

Implementing operations of the Proposed Action will not substantially change environmental baseline conditions for the distribution and abundance of piscivorous fish in the CRS. Thus, while outmigrating SR

steelhead are anticipated to continue to be exposed to predation in the CRS, conditions under the Proposed Action are not anticipated to worsen. On one hand, fish in the dam tailraces that may be particularly susceptible to predation could benefit from the flex spill program through increased spill discharge increasing turbulence immediately downstream of the dams, making it more difficult for predators to locate and prey upon juvenile salmonids in these areas. On the other hand, increased spill discharge may increase disorientation of outmigrants in spillway tailwaters, leading to increased vulnerability to avian predation.

Efforts to minimize predation by birds and pikeminnow will continue with the Proposed Action. In 1990, the Action Agencies began a program to reduce predation by northern pikeminnow by removal at the dams and a sport reward program that pays anglers for pikeminnow removed. 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. Avian dissuasion actions at the dams (e.g., wires, sprinklers, etc.) will also continue with implementation of the Proposed Action. Collectively, these efforts are intended to reduce predation rates on outmigrating juvenile SRB steelhead through the CRS.

Juvenile steelhead survival is expected to increase by up to 5% through the John Day Reservoir during the spring migration period as a result of deterring Caspian tern nesting at Blalock Island Complex with increased reservoir elevations as defined by the proposed action (see Chapter 2) (Evans et al. 2019). Increased reservoir elevations are expected to decrease travel rates through the John Day reservoir. Decreased travel rates may increase vulnerability to predation by piscivorous fish.

Non-Operational Conservation Actions

Predation Management

Management efforts to reduce predation by birds and northern pikeminnow will continue with the Proposed Action. Collectively, these efforts are intended to continue to minimize predation rates on outmigrating juvenile SR steelhead passing through the CRS.

Bird predation is a significant environmental baseline source of mortality for SR steelhead (Evans et al. 2018). The Action Agencies have developed various plans to help minimize predation by birds. In 2014, the Inland Avian Predation Management Plan (IAPMP) began (Corps 2014a). This plan manages avian predation on juvenile salmonids as they migrate to the ocean by reducing bird nesting colonies in inland areas by installing a variety of passive nest dissuasion materials prior to nesting seasons (Evans et al. 2018). A double-crested cormorant management plan for East Sand Island in the estuary was completed in 2015. And, avian dissuasion actions at the dams (e.g., wires, sprinklers, etc.) will continue with the Proposed Action.

Based on PIT-tag recoveries at East Sand Island in the lower estuary, average annual tern and cormorant predation rates for SR steelhead were about 22.2 and 9.3 percent, respectively, before efforts to manage the size and nesting location of these colonies (Evans et al. 2018). Previous management actions implemented by the Action Agencies to relocate various tern colonies has had some positive effect by reducing the predation rate on SR steelhead to 9.5 percent (Evans et al. 2018). Efforts to minimize predation by birds will continue with the Proposed Action. The flex spill program may also decrease

predation in CRS dam tailraces by increasing the turbulence downstream of the dams, making it more difficult for birds to locate and prey upon juvenile salmonids.

The northern pikeminnow, a native fish, is a significant predator of juvenile salmonids in the Columbia River. In 1990, the Action Agencies began the Northern Pikeminnow Management Program (NPMP) to reduce predation on juvenile salmonids by northern pikeminnow through targeted removal of northern pikeminnow at mainstem CRS dams. In addition, a Pikeminnow Sport Reward Fishery program has been instituted that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake Rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. Incidental catch of ESA-listed salmon and steelhead as a result of implementing pikeminnow management programs has occurred in the past and is likely to continue at a similar rate in the future. While the numbers are low, some individuals are likely part of the SR steelhead DPS.

Predator management programs will continue under the Proposed Action. They are anticipated to continue to maintain benefits achieved to date for reducing consumption of juvenile salmon and steelhead by avian and fish predators. The proposed measure at John Day to inundate the Blalock islands to dissuade tern nesting would benefit spring migrating salmon and especially steelhead. Further, continuing to implement the Caspian tern and cormorant management plans and the NPMP will result in negligible changes in predation but will prevent the impacts from “backsliding” to levels that were occurring prior to the Action Agencies implementation of these plans.

Juvenile SR Steelhead Estuary Migration and Rearing, Including the Plume

Estuarine and nearshore ecosystems provide habitat for juvenile steelhead to forage and avoid predators. Most juvenile steelhead move through the estuary in 1 or 2 days, and survival in this reach appears to be high (Daly et al. 2014), excluding mortality associated with avian predation.

Operations of the CRS have led to changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, the effects of CRS water management in the estuary are generally attenuated below Longview, WA, due to the distance from the facilities and inflow from tributaries like the Willamette and Cowlitz Rivers. Thus, any direct impacts from flow or elevated TDG in this area are expected to be negligible.

In addition, there is an apparent relationship between plume characteristics at time of ocean entry and SARs for steelhead. Jacobson et al. (2012) found that steelhead SARs increased with the size and offshore distance of the plume under favorable large-scale ocean conditions, but did not change when ocean conditions were poor (Jacobson et al. 2012).

Avian predation continues to be a serious issue in the estuary and juvenile steelhead appear to be targeted to a larger degree than other species. Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary will benefit this DPS by reducing the number of individuals of this DPS eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1]. Although the estuary habitat actions will continue, this DPS moves through the estuary so quickly that benefits from this work are likely low.

The indicators used below to assess the effects of the Proposed Action on juvenile SR steelhead migration through the estuary and plume are categorized as operational (survival, fish travel time, TDG, temperature, turbidity, and predation) and non-operational (predation management and fish status and trend monitoring). Using these indicators, analyses of effects to SR steelhead during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Survival

Fish use in the estuary likely affects their subsequent survival in the ocean. Monitoring and research suggests that fish size and time of ocean entry, which are in part due to conditions in the estuary, can affect salmon growth and survival in the ocean (Chittaro et al. 2018; Johnson et al. 2018). Habitat enhancements that improve capacity (e.g., prey productivity) may lead to increased growth and improved condition of migrating juvenile salmonids in the estuary. The improved condition of fish in the estuary can contribute to increasing the likelihood of their survival into the ocean.

Fish Travel Time

Changes in CRS water management in the Proposed Action are not expected to alter fish travel time through the estuary. Therefore, under the Proposed Action, travel time in the estuary of juvenile SR steelhead is not likely to change from the baseline condition.

Total Dissolved Gas

Changes in CRS water management in the Proposed Action are not expected to alter fish travel time through the estuary. Therefore, under the Proposed Action, travel time in the estuary of juvenile SR steelhead is not likely to change from the baseline condition.

Temperature

Changes in CRS water management in the Proposed Action are not expected to alter fish travel time through the estuary. Therefore, under the Proposed Action, travel time in the estuary of juvenile SR steelhead is not likely to change from the baseline condition.

Turbidity

Implementing the Proposed Action is not likely to affect turbidity levels in the estuary and plume.

Predation Rates

The Proposed Action is not anticipated to have any effect on the rate of predation of juvenile salmonids in the Columbia River except, potentially, in the tailraces during higher spill periods (reducing predation; see above). Continuing to implement the Caspian tern and cormorant management plans, as well as the NPMP, will result in negligible changes in predation but will prevent the impacts from “backsliding” to levels that were occurring prior to the Action Agencies implementation of these plans.

Non-Operational

Predation Management

The Proposed Action will continue to implement the various predator management programs that are currently being implemented in the estuary and mainstem Columbia River. Some ESA-listed fish are captured as part of implementing the Pikeminnow Sport Reward Fishery and dam angling program. The number of individual fish impacted is likely to continue at a similar rate in the future. While the numbers are low across the entire program, some individuals below Bonneville Dam and in the estuary may be captured, injured, or killed.

Hatcheries

As discussed previously, the effects of hatchery fish on natural-origin fish in the Columbia River estuary and the Pacific Ocean is still poorly understood, and available knowledge and research abilities are insufficient to discern any important role or contribution of hatchery fish in density-dependent interactions affecting salmon and steelhead growth and survival in the mainstem Columbia River, the Columbia River estuary, and the Pacific Ocean. As discussed above, NMFS (2016f) concluded that the

... influence of density-dependent interactions on the growth and survival of salmon and steelhead is likely small compared with the effects of large-scale and regional environmental conditions. While there is evidence that large-scale hatchery production can affect salmon survival at sea, the degree of effect or level of influence is not yet well understood or predictable. The same thing is true for mainstem rivers and estuaries.

Estuary Habitat Actions

As part of the Proposed Action, the Action Agencies will continue implementing the Columbia Estuary Ecosystem Restoration Program (CEERP) to improve estuary floodplain habitats, including tidally influenced portions of tributaries, used by outmigrating salmon and steelhead. The planned improvements in habitat functions are expected to provide long-term benefits to native species that use these habitats through improved ecological functions and processes. Appropriate ESA consultation is typically undertaken prior to implementation of these projects at site-specific scale. These ESA consultations are complete with implementing Terms and Conditions that the Action Agencies comply with. Project effectiveness is expected to increase over time as the restoring habitats mature and new, more effective restoration projects are implemented, because program sponsors will be taking into account lessons learned from previous projects within CEERP's adaptive management framework (Diefenderfer et al. 2016).

Diefenderfer et al. (2013) evaluated whether juvenile fish that use the estuary were responding favorably to the restoration actions. They used a "line of evidence" approach and concluded the following:

- Hydrologic reconnections restore access for fish to move into a site to find prey produced there. Reconnections also restore the potential for the flux of prey from the site to the mainstem river, where data show that they are consumed by salmon.

- Restoration supports increased juvenile salmon growth and enhanced fitness (condition), thereby potentially improving survival rates during the early ocean stage.
- Ongoing cumulative impacts from urbanization and decreased forest cover, which although outside of the control of the CEERP, could impair the development of resilient ecosystems on the river floodplain.
- The habitat restoration activities in the lower Columbia River and estuary are likely having a cumulative beneficial effect on juvenile salmon, including interior basin salmon.

Implementation of the Proposed Action will continue habitat restoration efforts that are benefitting juvenile salmonids. Project effectiveness is expected to increase over time as existing projects mature and new ones are implemented.

Fish Status and Trend Monitoring

The RM&E component of CEERP includes actions to monitor status and trends of habitat and fish, perform action effectiveness monitoring and research, and conduct critical uncertainties research. CEERP is implemented using an adaptive management process to capture learning from RM&E and adjust accordingly program strategies and actions (Johnson et al. 2018). RM&E will continue under the Proposed Action. Capture and handling of juvenile salmon and steelhead, some of which are likely SR steelhead, may result in stress, injury, harm, and in extreme cases, death as part of RM&E in the estuary and plume.

Ocean Rearing

SR steelhead typically spend 1 to 2 years maturing in the ocean, with A-run fish usually residing within the marine environment 1 year, and B-run fish residing 2 years. CRS management has no *direct* influence on survival of SR steelhead in the Pacific Ocean. There are, however, a small number of individual salmon and steelhead that could experience deleterious direct effects from capture and handling from a Bonneville-funded study of juvenile salmonid ecology in the plume and nearshore ocean. *Indirect* effects on survival of SR steelhead from CRS management include any latent/delayed mortality manifested in the ocean and the positive influence CRS management can have on juvenile migration and growth in the estuary, which is related to improved survival during early ocean entry.

The Proposed Action will have no effect on the ocean habitats used by SR steelhead for growth and maturing, because there are no CRS operations that affect this area (the Columbia River plume was addressed above).

Adult SR Steelhead Migration to Bonneville Dam

While no indices of migration rate from coastal waters to Bonneville Dam exist for SR steelhead, NMFS reported that SR spring/summer Chinook took, on average, 18.1 days in 2011 and 15.4 days in 2012 to navigate that reach of river (NMFS 2014a). It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River by the distance from the facilities and the streamflows from lower river tributaries like the Willamette River. The Proposed Action causes no

adult migration barriers for SR steelhead adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. Thus, the Proposed Action is likely to have negligible effects on SR steelhead adult migration from the ocean to the CRS.

Further analysis of effects to adult SR steelhead returning to the Columbia River and migrating up to Bonneville Dam as a result of implementing the Proposed Action is described next. The analysis is organized by operational and non-operational components.

Operational

Survival

The Proposed Action is not expected to negatively affect the migration corridor and, hence, survival for adult UCR steelhead in the estuary (Bonneville Dam to the ocean).

Travel Time

The Proposed Action is not expected to alter the migration rate of adult SR steelhead in the estuary. The Proposed Action will result in negligible flow reductions and, thus, a minor reduction in water particle velocity at the time adult steelhead will be entering and migrating through the lower Columbia River. Therefore, the Proposed Action is not expected to result in a measurable increase or decrease in migration rate.

Total Dissolved Gas

As a result of the flex spill operation during spring, early migrating adult UCR steelhead will be exposed to slightly elevated TDG levels. Most adult SR steelhead, though, enter the Columbia River from the ocean in July and August, after the flex spill program has concluded, and, as such, will not be exposed to potentially elevated levels of TDG. Therefore, based on the attenuating effect on TDG of distance downstream of the CRS, the influence of tributary streamflow, and the timing of adult SR steelhead migration to Bonneville Dam, the Proposed Action are not expected to adversely affect adult SR steelhead in the estuary during migration to Bonneville Dam.

Temperature

Poor water quality, which includes increased water temperature, can lead to stress in adult SR steelhead. This, in turn, can lead to reductions in biological reserves, altered physiological processes, increased disease susceptibility, and decreased performance of individual fish (e.g., growth). Furthermore, elevated water temperatures can affect salmonid distribution, behavior, migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult UCR steelhead (NMFS 2019).

Effects of the Proposed Action are not expected to result in elevated water temperatures downstream from Bonneville Dam and, therefore, are not likely to negatively impact adult SR steelhead within this reach.

Turbidity

Existence of the CRS has decreased sediment loads transported downstream by the Columbia River. In fact, it is estimated that the total sediment discharge into the estuary and the Columbia River plume is approximately one-third of pre-hydrosystem levels (NMFS 2019).

Effects of the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam and, therefore, are not likely to negatively impact adult SR steelhead within this reach.

Non-Operational

Predation Management

For upstream migrating SR steelhead, the primary factor in the estuary affecting survival to Bonneville Dam is pinniped predation. The existence of Bonneville Dam, which is part of the environmental baseline, likely causes pinnipeds to congregate downstream from that project. However, if Bonneville Dam were not present, the pinnipeds would likely congregate at Cascade Falls or other upstream falls, much like they do at Willamette Falls. Estimates of pinniped predation downstream of Bonneville Dam are not available for adult SR steelhead; however, salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). In a study assessing pinniped predation on adult salmonids and other species, Tidwell et al. (2018), estimated a consumption rate of 1.54 percent for all steelhead collectively and concluded that the estimate is a reasonable rate of consumption on SR steelhead.

Measures intended to reduce predation on adult salmonids, such as hazing, removal, and the continued use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates), will continue under the Proposed Action. Furthermore, if pinnipeds are observed in the tailrace of The Dalles Dam, hazing efforts may be implemented at that project's ladder entrances. No components of the Proposed action are expected to result in a change associated with pinniped predation.

It is anticipated that the Action Agencies will continue to implement the NPMP, as well as the Sport Reward Fishery in the lower Columbia River estuary, and that steelhead, including some SR steelhead, will be handled and/or killed during those activities. However, these activities are expected to maintain the 30 percent reduction in predation rates achieved under the 2008 RPA (NMFS 2019). These programs are a continuation of existing programs and are not part of the Proposed Action.

Adult SR Steelhead Migration Through CRS Dams

Most Snake River Basin steelhead populations will migrate upstream through all eight Lower Columbia and Snake River CRS projects on their way to spawn. The one exception is the Tucannon River population, which will migrate through the Lower Columbia projects, plus Ice Harbor and Lower Monumental dams. Many of the 2008 BiOp actions were directed at improving migration conditions for

returning adult fish, which are especially valuable to the listed species since they have survived high-mortality life stages, such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

As reported earlier, after accounting for reported harvest rates and expected stray rates, adult SR steelhead have relatively high survival rates passing the Lower Columbia and Snake River CRS dams [six CRS projects for the Tucannon population; (NMFS 2019)]. Based on conversion rates of PIT-tagged SR steelhead detected at Bonneville Dam for the years of 2008 to 2017, the estimate of minimum survival for the Bonneville to McNary reach averaged 94.3 percent over the 10-year period (range of 90.1 to 100.0 percent). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 98.1 percent per project (NMFS 2019). Based on the same dataset, the minimum survival estimate for the Bonneville to Lower Granite Dam reach has been estimated to be 86.6 percent (range of 81.2 to 94.1 percent). Based on this estimate of reach survival, per project survival averages 97.9 percent.

An analysis of effects to adult SR steelhead migrating upstream through the CRS as a result of implementing the Proposed Action follows. The analysis is organized by operational and non-operational components.

Operational

As discussed previously, the Proposed Action includes a flex spill program for spill at CRS projects to a level where the state water quality limit for TDG is met 16 hours per day and a performance spill component is implemented 8 hours per day. The flex spill program will occur April 3 through June 20 at the lower Snake River projects and April 10 through June 15 at the lower Columbia River projects.

Other components of the Proposed Action include structural measures such as modifying the Bonneville ladder serpentine weir (to reduce delay within the fishway) and the flexibility to increase the reservoir drawdown within the lower Snake River and John Day reservoirs by 0.5 feet (to increase water particle velocity and, therefore, reduce juvenile travel time). Collectively, these measures have the potential to impact SR steelhead.

Modeling Results

Limited modeling was completed for adult SR steelhead. The NWFSC LCMs for steelhead are still in development and are not available for this analysis, and CSS LCM modeling is only available for the NAA and preferred alternatives. CSS modeling predicts that, for current conditions, the Lower Granite to Bonneville Dam SAR would be 1.8, and for the preferred alternative, the predicted SAR would be 1.9 (an increase of 5 percent). The SAR value represents the percentage of smolts passing Lower Granite Dam that survive to return as adults to Bonneville Dam. Based on COMPASS and CSS modeling, travel time and juvenile survival of UCR steelhead under the preferred alternative conditions would be similar to the current conditions, meaning a similar number of juveniles would arrive at the ocean with timing similar to current conditions. As such, it is reasonable to assume that SR steelhead adult abundance under the preferred alternative would also be similar to the current condition.

Fallback

Adult SR steelhead can fallback at dams while migrating upstream to their natal streams or as they migrate downstream as kelts. Typical fallback occurs after an individual ascends a fishway and then passes back downstream from the project in a relatively short period of time. This activity is often associated with higher spill levels at the project. As such, fallback tends to be higher for earlier migrants and kelts that encounter projects during the spill season, compared to later migrants that encounter projects after the spill season has concluded (Keefer et al. 2016). For adult SR steelhead, mean annual fallback rates at lower Columbia River dams is about 6 to 9 percent and about 3 to 6 percent at lower Snake River dams (Keefer et al. 2016).

The Proposed Action, specifically the flex spill component, will have the potential to increase the rate of fallback at CRS dams. With increased spill, it is likely more of the fish that fallback at a given project will do so through the spillway, or some surface-oriented passage route. However, spill at lower Columbia River dams will terminate on June 15 and on June 20 at Snake River dams. For fish that do fallback during the flex spill program, and specifically through the spillway or a surface structure, survival of that fallback event is relatively high. At Bonneville Dam, direct survival tests using rainbow trout as a surrogate revealed that, for fish passing downstream of the dam via the Ice/Trash sluiceway and the corner collector, survival was greater than 98 percent (after 48 hours). At McNary Dam, direct survival was estimated to be approximately 98 percent through the TSW. Conversely, direct survival through the McNary turbines was estimated to be approximately 91 percent (Keefer et al. 2016). For later migrating fish (i.e., those that ascend the CRS after termination of the flex spill program), rate of fallback is not expected to change.

In sum, the Proposed Action has potential to negatively affect SR steelhead by increasing fallback.

Total Dissolved Gas

Populations of SR steelhead enter the Columbia River estuary and pass over Bonneville Dam as early as May, but most migrants are observed from June 1 through the end of October, with peak migration in mid-August (Keefer et al. 2016). Since the flex spill program will occur April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects, most adult SR steelhead will not be exposed to elevated levels of TDG. However, earlier migrating adult SR steelhead will likely be exposed to elevated TDG levels.

As described in the previous section, GBT is not typically observed when TDG levels do not exceed state water quality standards of 120 percent and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Based on the limited observations of GBT at expected TDG levels associated with the Proposed Action, and given the migrational timing of adult SR steelhead within the CRS, the Proposed Action is not expected to result in an elevated risk of GBT to SR steelhead.

Temperature

As described previously, poor water quality, which includes increased water temperature, can lead to stress in adult SR steelhead, which in turn can lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth and osmoregulation). Furthermore, elevated water temperatures can affect salmonid distribution, behavior,

migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult SR steelhead (NMFS 2019).

Major factors that influence water temperatures within the Columbia River Basin include natural variations in weather and river flow; the existence of the hydroelectric system; increased tributary temperatures because of irrigation, grazing, and logging; urbanization and population growth; and projected increased air temperature because of climate change. The extent that these variables influence water temperatures within the CRS is expected to increase as urbanization and population growth increase and the effects of climate change become more pronounced. However, implementation of the Proposed Action is not expected to alter water temperatures within the CRS.

As discussed above, releasing cooler water from Dworshak Dam in the summer cools the mainstem Snake River, which decreases potential negative effects of increased water temperature on adult migration. Under the Proposed Action, reservoir operations at Dworshak will continue to cool temperatures in the lower Clearwater River and lower Snake River reservoirs during summer to improve environmental conditions for adult migrants.

Because actions associated with the Proposed Action will not result in elevated water temperatures within the CRS, effects of the Proposed Action are not expected to affect adult SR steelhead within this reach.

Turbidity

Hydropower development in the Pacific Northwest has altered the extent of sediment transport downstream through the Columbia River, including within the CRS. While other anthropogenic activities, such as agriculture, irrigation, mining, logging, road building, etc., have increased sediment delivery to the mainstem Columbia River, both federal and non-federal projects act as sediment traps, decreasing sediment loads discharging downstream. These activities and baseline conditions are expected to continue at current rates.

Because actions associated with the Proposed Action are not expected to result in changes in baseline sediment load, the Proposed Action is not expected to affect adult SR steelhead within the CRS.

Non-Operational

Predation Management

Predation on adult SR steelhead within the CRS is rare, with pinnipeds being the primary predator. While pinniped predation commonly occurs within the tailrace of Bonneville Dam downstream to the Pacific Ocean, pinniped observations upstream from Bonneville Dam are not common.

Measures intended to reduce predation on adult salmonids, such as hazing, removal, and use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates), will continue. Furthermore, if pinnipeds are observed in the tailrace of The Dalles Dam, hazing efforts may be implemented at that project's ladder entrances. No components of the Proposed Action are expected to result in a change associated with pinniped predation.

In addition, predator fish management programs, like the NPMP, could potentially effect SR steelhead as by-catch, while the number of pikeminnow are being indexed through electroshocking. Based on past observations, NMFS is unable to estimate the number of SR steelhead that will be affected by this action. However, it is anticipated that the current level of take will continue for the duration of this Proposed Action (NMFS 2019). No components of the Proposed Action are expected to result in a change associated with this activity.

Adult SR Steelhead Migration Upstream of the CRS to the Spawning Areas

Operational

After migrating upstream through the CRS, adult SR steelhead begin to migrate to their natal streams. Once they enter those tributaries, they are no longer exposed to the operation and related effects of the CRS.

Non-Operational

Within SR steelhead tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this DPS. The following provides a description of the effects of those actions.

Hatchery Programs

There are a total of 13 steelhead hatchery programs within the Snake River Basin, as well as one kelt reconditioning program (implemented at the Nez Perce Tribal Fish Hatchery [that is funded by Bonneville]). Of those programs, five are included in the DPS (NMFS 2019). All programs (funded by Idaho Power, USFWS, and through the Lower Snake River Compensation Program [LSRCP]) have been through or are in the process of separate ESA consultations.

Hatchery programs may provide short-term benefits, such as increasing abundance, especially during periods of low natural abundance, and can also help preserve genetic integrity of a population until other limiting factors can be resolved. However, long-term implementation of hatchery programs can also negatively affect populations (NMFS 2019).

Tributary Habitat Actions

For Snake River Basin steelhead, habitat degradation is the result of past and present anthropogenic activities. Tributary habitat for SR steelhead varies significantly throughout the Snake River Basin. In some areas, habitat is minimally degraded; in other areas, it is highly degraded; and in still other areas, spawning and rearing habitat is in near-pristine condition.

As described previously, many factors limit the viability of this DPS. In response, many habitat measures have been implemented specifically to benefit SR steelhead by federal, state, local, and private entities, including the Action Agencies. Since 2007, the Action Agencies have

- Protected 58,854 acre-feet of water through efficiency improvements and water purchase/lease projects

- Protected 2,204 acres through land purchases or conservation easements
- Treated 6,210 acres to improve riparian habitat
- Enhanced or made accessible 1,037 miles of habitat by providing passage or removing barriers
- Improved 165 miles of stream complexity
- Protected 179 miles of habitat through land purchases or easements
- Installed or addressed 69 screens.

Based on the best available science, NMFS has concluded that these actions have improved, and will continue to improve, habitat for SR steelhead as these projects mature. Furthermore, that fish population abundance, productivity, spatial structure, and diversity should respond positively (NMFS 2019).

Passage Emergency Operation

If a SR sockeye salmon passage emergency operation is declared due to high water temperatures at the Snake River projects, some juvenile steelhead may be collected and incur mortality incidental to the process of collecting and sorting adult sockeye. Injury is expected to be low. If a SR sockeye salmon passage emergency operation is declared, impacts may be similar to those estimated in 2015; less than 50 steelhead may be injured per day from mid-July to early August (NMFS 2015).

Fish Status and Trend Monitoring

It is anticipated that the Action Agencies' RM&E program will continue at current levels of effort or, perhaps, at somewhat reduced levels. As such, the level of injury and mortality associated primarily with the capture and handling of SR steelhead is expected to be maintained at current or slightly decreased levels. Those impacts are summarized in the 2019 BiOp (NMFS 2019) and include the following:

- Projected estimates of SR steelhead handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) 5 hatchery and 5 wild adults handled; and (2) zero hatchery or wild adults killed.
- Projected estimates of SR steelhead handling and mortality during activities associated with Fish Status Monitoring: (1) 23,371 hatchery and 11,479 wild adults handled; and (2) 234 hatchery and 115 wild adults killed.
- Projected estimates of SR steelhead handling and mortality for all other RM&E programs: (1) 1,519 hatchery and 387 wild adults handled; and (2) 15 hatchery and 4 wild adults killed.

Implementation of the Proposed Action will not alter fish monitoring programs associated with SR steelhead and, as such, no effects of these actions are anticipated for this DPS.

Adult Steelhead Downstream Passage (Kelts)

Anadromous steelhead in the Columbia River have multiple life history strategies including iteroparity. Iteroparity involves the downstream migration of post spawned steelhead (kelts) that return to the ocean or estuary environments for a period of time before spawning again. Kelt returns can be affected

by the extreme energetic demands of spawning and iteroparity, harvest (which may affect spawn timing and location), and the Columbia Basin hydrosystem (Colotelo et al. 2014). Most studies of adult survival carried out at Columbia River dams have used overwintering summer run steelhead (Khan et al. 2009; Ham et al. 2012a, b; Khan et al. 2013), hence CRS related mortality specifically for downstream migrating kelts is not as well-known at this time. The Corps conducted a direct survival test of adult steelhead passing through McNary dam in 2014; mean survival rates were 97.7% through the spillway weir route, and 90.7% via the turbine route, for overwintering adults presumed to be in good condition (Normandeau 2014). As part of a two year study, Colotelo et al. (2013) estimated that 45 percent of SR steelhead kelts survived from the Lower Granite forebay to the Bonneville dam face (RM 234) and 41 percent of the lower Columbia River (RM156), respectively. An estimated 67 percent of kelts survived from the McNary forebay to the Bonneville Dam face (Colotelo et al. 2013). River conditions were warmer with lower flow in the second year of the study in 2013; mean survival rates between Lower Granite Forebay and the lower Columbia River were somewhat lower (approximately 27%) and rates of travel were slower (Colotelo et al. 2014). In both years, smaller sized steelhead had better rates of survival; it was uncertain whether this resulted from a higher rate of injuries to larger bodied steelhead in dam passage routes, or whether larger fish were in poorer post-spawn condition.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Effects of the Proposed Action on critical habitat for SR steelhead were assessed based on the action's elements likely to affect PBFs essential for the conservation of the DPS. Effects cover critical habitat for tributary spawning and rearing, the freshwater migration corridor through the mainstem CRS dams, and the estuary and nearshore ocean.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of SR steelhead. Freshwater spawning and rearing areas occur upstream of the CRS, so the effects of the Proposed Action are limited to tributary habitat mitigation actions, which are intended to improve habitat function for SR steelhead. For the tributary habitat program, there will be some uncertainty about the actual locations, extent, and types of tributary habitat actions that will be implemented as part of the Proposed Action. However, anticipated effects of the tributary habitat improvement program are expected to include short-term and will be mitigated through compliance with BiOp on Columbia River habitat improvements (NMFS 2013), temporary impacts associated with stream restoration activities, and long-term positive effects associated with the tributary habitat program. Effects to critical habitat within the SR from kelt reconditioning programs and nine steelhead hatchery programs, as well the operation and maintenance of these programs, have undergone separate, program-specific ESA consultation with NMFS (NMFS 2017b).

Freshwater Migration Corridors

Freshwater migration corridors are used by returning adult steelhead migrating upstream through the CRS and by juvenile steelhead migrating downstream. The CRS dams and reservoirs have affected and will continue to affect critical habitat within the mainstem Columbia and Snake Rivers, which continues

to influence passage and survival of juvenile and adult migrants. The Proposed Action includes ongoing implementation of the Action Agency's predator management programs, which is intended to reduce the consumption of juvenile and adult salmon within the CRS and estuary. These programs will continue to reduce the risk of predation on SR steelhead.

The Proposed Action also includes both structural and operational modifications to the CRS that will affect water quality and passage conditions that SR steelhead must migrate through to complete their life cycle. The overall effects of the Proposed Action are slightly positive, with respect to passage conditions and risk of predation, and slightly negative relative to a higher exposure to TDG and potential incidence of GBT. Continued effects to stream temperature, sediment, and turbidity are anticipated with the CRS, but effects to those water quality indicators are likely to remain unchanged as a result of the Proposed Action. Passage conditions at each of the projects are anticipated to improve for juvenile steelhead, as the flex spill program will provide more advantageous passage routes through spill bays at each of the projects. Increasing the proportion of water discharged through the spill bays at each of the dams will reduce forebay residence time by providing a more pronounced surface-oriented flow path for juvenile steelhead, which, it is hypothesized, will reduce latent mortality.

Estuarine and Nearshore Ocean Areas

Estuary and nearshore ocean areas have been designated as essential for the conservation of SR steelhead. Ongoing implementation of the Columbia Estuary Ecosystem Restoration Program and predator removal and harassment programs is anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of the CEERP is likely to increase the capacity and quality of habitat in the estuary while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal and harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to improve the safe passage feature of critical habitat.

The Proposed Action includes operational modifications to the CRS that may affect water quality downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions with a slight but potential increase in TDG associated with the flex spill program. The highest TDG levels (125 percent) are expected in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). In juvenile salmon, an increase in TDG will potentially increase the incidence of GBT. Adult SR steelhead are likely to be unaffected by the flex spill program due to their upstream migration timing. Continued effects to stream temperature, sediment, and turbidity are anticipated downstream from the CRS but are likely to remain unchanged from the current condition as a result of the Proposed Action. Current passage conditions will be unaffected for juvenile and adult SR steelhead as they migrate through the Columbia River estuary.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on SR steelhead in the context of existing conditions and cumulative effects. Cumulative effects are effects of future state or private activities that

are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline condition (whether they are federal, state, or private). To the extent those same activities are reasonably certain to occur in the future (and are state or private), their future effects are included in the cumulative effects analysis.

Most of the action, baseline, and cumulative effects identified in the analysis above are consistent with effects previously described for operation of the CRS in past consultations. In general, the Proposed Action as a whole is not likely to limit species survival or critical habitat function. It carries forward a suite of beneficial actions that improve baseline conditions and offset negative effects attributable to the regulation of flows, including flow augmentation, fish passage operations, predation management, and habitat improvement. Though the Proposed Action does not cause substantial changes to current species conditions, there may be some modest site-specific effects from the continued operation of the CRS. It is also possible that increased spill levels, and associated adverse effects, will be offset by an increase in adult returns due to less powerhouse encounters as hypothesized by the CSS.

The summary below will follow the general structure of the analysis above and will discuss each factor that was previously evaluated.

Survival

Survival of juvenile SR steelhead through the CRS is affected by the number of hydroprojects they pass, predators, travel time, and water quality. These factors are the result of the existence and continued operation of the CRS. Survival has improved for juvenile SR steelhead migrating through the CRS to the ocean as a result of past actions. Juvenile steelhead survival has also improved in the estuary and tributaries due to habitat improvements implemented by the Action Agencies. For adult SR steelhead, survival is affected in the estuary up to Bonneville Dam by pinniped predators.

Future state and private actions, and the effects of climate change and variable ocean conditions, have the potential to effect survival of SR steelhead. Land use activities (primarily private) have the potential to affect juvenile survival by decreasing tributary and estuary habitat or degrading abiotic factors such as temperature. Further degradation of tributary habitat could also affect adult SR steelhead survival by reducing holding and spawning areas or development of passage barriers. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies implement fisheries that can have a direct effect on the number of returning steelhead to the SR tributaries (and in some cases, within the tributaries themselves).

It is anticipated that survival gains that have resulted from previous actions will continue and possibly increase by continuing tributary and estuary habitat actions, as well as continued improvement to juvenile and adult passage conditions at the CRS dams. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications to actions.

Travel Time

The building and operation of the CRS has slowed juvenile travel time compared to the pre-CRS condition, potentially increasing exposure to predators as they migrate through the CRS. Travel time

within the tributaries and estuary are not affected by the CRS. While travel time of SR juveniles within the CRS varies from year to year, actions from the past that are on-going send more fish through non-turbine routes, which is believed to decrease travel time and improve survival. Adult travel time is not considered an issue. However, increased water temperatures may lead to migrational delays at fishways, which may reduce spawning success.

Future state and private actions are not expected to affect travel time of juveniles or adults through the CRS during any life stage. However, it is anticipated that projected increased air temperatures due to climate change will likely continue to increase overall temperatures in the Columbia River and, therefore, have the potential to further affect adult SR steelhead upstream migrational timing and possibly juvenile emigration timing.

The Proposed Action is anticipated to reduce forebay resident time for juvenile SR steelhead migrating past CRS hydroprojects during the flexible spill plan implementation. Continued monitoring of adult SR steelhead migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse Passage Proportion

Past and current physical modifications and operations of the CRS hydroprojects has increased the percentage of juvenile fish passing non-turbine routes. Decreasing powerhouse passage improves survival of juveniles during their downstream migration and earlier migrating adults that may fallback and have to migrate upstream past a dam again (by falling back through spill rather than the powerhouse).

The effects from state and private actions are not anticipated to affect juvenile SR steelhead powerhouse passage.

The Proposed Action will continue the operations and actions that have resulted in increased non-turbine passage at the CRS projects. Additional powerhouse surface passage routes and upgraded adjustable spillway weirs at Lower Granite, Lower Monumental, Ice Harbor, McNary, and John Day dams will improve juvenile passage and offer greater range of operations of surface-oriented passage throughout the migration season. In addition, as techniques and additional operations are considered, further increases in non-turbine passage could occur.

Water Quality

Total Dissolved Gas

Total dissolved gas has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high levels that resulted in GBT in juveniles and adults as they migrated through the CRS. Elevated TDG levels are not observed within tributaries or the estuary (where the effects of CRS operations on TDG are attenuated by distance and tributary inflow). The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

The only state or private actions that will affect TDG levels in the mainstem Columbia River are modifications to state water quality criteria. For example, in 2020, it is anticipated that the Washington and Oregon water quality agencies will increase the allowable maximum level of TDG in the tailraces of CRS dams from 120 to 125 percent. Continued monitoring of juveniles and adults for signs of GBT will inform managers on the effects of this action.

It is anticipated that implementing the flexible spill program will elevate TDG levels to the state water quality limit, which may slightly increase the incidence of GBT in juvenile fish.

Temperature Changes

Water temperatures have been modified as a result of a range of anthropogenic activities, including the existence and on-going operation of the CRS, throughout the Columbia River Basin. Increases in temperature can have a range of effects on both juvenile and adult SR steelhead.

On-going non-federal land management activities that affect temperature, such as agriculture, urbanization, and forestry, are not expected to improve substantially. However, small improvements may be realized from tributary actions that restore and preserve habitat, like riparian plantings.

Implementation of the Proposed Action will continue to improve tributary temperatures but will continue to have minimal effect on mainstem temperatures.

Turbidity Levels

Currently, sediment loads in tributaries have been affected by historical land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and rearing habitat. In the mainstem Columbia and Snake Rivers, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk.

In the tributaries of the Snake River, non-federal actions are likely to continue to affect turbidity; however, improvements in tributary habitat included in the Proposed Action are expected to result in reduced sediment inputs, resulting in modest, site-specific improvements that will mitigate continued activities that degrade habitat. In the CRS, the current condition is not anticipated to change, and no non-federal activities are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment levels in the tributaries. In the CRS, it is not anticipated that the Proposed Action will change the current condition.

Dam Passage (Adults)

Currently, SR steelhead migrate upstream through CRS projects on their way to natal spawning areas and experience a variety of factors affecting them, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish. Current adult passage conditions should improve with modifications at Bonneville and Lower Granite dams fishways, which should help reduce delay. Installation of pumping systems to provide cool water in adult fish ladders at Lower Monumental and Ice Harbor dams should also improve adult

passage conditions within the CRS. SR steelhead appear to survive their migration through the CRS at high levels and those survival rates are expected to continue with implementation of the Proposed Action. In addition, steelhead that survive spawning and migrate back to the ocean (kelts) can be affected by the CRS. Kelts should benefit from the flex spill program, because surface-oriented passage routes through the spillways should guide more juveniles and adults (e.g., kelts) away from powerhouse passage routes.

Non-federal actions that have the potential to affect SR adults migrating through the CRS include continued degradation of tributary habitat that increase temperatures and projected increases in air temperature due to climate change that will likely warm surface water temperatures.

The Proposed Action will continue to monitor adult migration through the CRS and use that information to propose specific actions that will increase adult survival.

Predation Rates

Currently, both juvenile and adult SR steelhead encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinniped predators' prey on adults as they enter the Columbia River from the ocean to the tailrace of Bonneville Dam. A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS, mostly in the tailraces of dams.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS has no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

The Proposed Action will continue to implement the predator management programs, which should ensure that predation does not worsen, and may reduce overall predation rates over time.

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to operation of hydro facilities, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin salmon and steelhead and their habitat depends on the design of hatchery programs, the condition of the habitat, and the status of the species, among other factors.

The majority of hatchery programs are run by the state in which they occur. It is anticipated that most of the current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue.

The Proposed Action does not include hatchery production programs for SR steelhead. Therefore, the Proposed Action does not include potential deleterious effects of hatchery-origin fish on natural-origin steelhead.

Predation Monitoring

Predation monitoring is implemented primarily to determine the effectiveness of the various predator management programs. Without this monitoring and evaluation, it would not be possible to understand whether the management programs are having the desired effect.

Monitoring predator programs is not anticipated to be affected by any non-federal actions in the future.

The Proposed Action will continue to fund and implement predator monitoring and evaluation programs that have been successful to date in determining the effectiveness of the current management programs.

Habitat Actions

Currently, habitat conditions in the tributaries, mainstem Columbia River, and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect SR steelhead include continued degradation of tributary habitat that increase temperatures and projected increased air temperatures due to climate change that will likely warm surface water temperatures.

The Proposed Action will continue to rehabilitate habitat in the tributaries and estuary.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on SR steelhead. These are associated with the capturing and handling of fish. Research, monitoring, and evaluation activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no non-federal actions anticipated that would affect RM&E activities.

The Proposed Action will continue to implement the RM&E programs that are currently occurring, with the potential to modify these programs in the future as the results of the monitoring programs are evaluated.

Summary

In Table 3-18, the Proposed Action is compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action.

Most of the actions are anticipated to either have no effect, or a positive effect compared to the baseline condition (Table 3-18). This is partly because the Proposed Action continues numerous beneficial actions developed over the preceding decade, including habitat improvement, flow augmentation, and fish passage operations. Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill

levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-18. Summary comparison of the Proposed Action to current conditions for SRB steelhead by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Steelhead Downstream Migration Through the CRS	Survival ⁸	x		-	Flexible spill plan is expected to slightly increase non-turbine passage.

⁸ The EIS COMPASS and CSS modeling results generally support the qualitative expectations that survival rates through the CRS will increase for both the MO1 and MO4 alternatives relative to the baseline condition (2016 NAA). The exception to this observation is a slight decrease in juvenile survival for the MO1 alternative based on COMPASS modeling (a decrease of 1.2 percent). For the same parameters, the CSS model predicts an increase in juvenile survival of 3.0 percent.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x	x	+	Increasing John Day Dam Reservoir elevations and continuation of predator management programs should decrease predation.
	Hatcheries	x	x	=	
	Predation monitoring	x	x	=	
	Fish status and trend monitoring	x	x	=	
Juvenile Steelhead Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Steelhead Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Steelhead Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce overshoot.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
Fish status and trend monitoring		x	=		
Adult Steelhead Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring		x	=	

3.1.2.4 Snake River Spring/Summer Chinook ESU

This section examines the status of the SR spring/summer Chinook, the status of SR spring/summer Chinook critical habitat, and the effects of the Proposed Action on SR spring/summer Chinook.

STATUS OF THE SNAKE RIVER SPRING/SUMMER CHINOOK ESU

The SR spring/summer Chinook ESU was first listed under the Endangered Species Act on June 3, 1992, at which time it was classified as threatened (57 FR 23458). That status was reaffirmed June 28, 2005 (70 FR 37160) and then again on April 14, 2014 (79 FR 20802). Critical habitat for the ESU was originally designated on December 28, 1993 (58 FR 68543), but was updated on October 25, 1999 (64 FR 57399).

The status of a species is based on an assessment of extinction risk and is a function of abundance, productivity, spatial structure, and diversity. Those parameters are, in part, included in listing decisions, status reviews, and recovery plans. While material from the most recent status review [NMFS (2016a) and 84 FR 49214 (2019) as cited in NMFS (2019)], the 2019 BiOp (NMFS 2019), and the SR spring/summer Chinook recovery plan [NMFS (2017a) as cited in NMFS (2019)] are incorporated here by reference, the following provides a brief summary on the current status of SR spring/summer Chinook.

This ESU includes all naturally spawned anadromous spring/summer Chinook populations in the mainstem Snake River, as well as the Tucannon, Grande Ronde, Imnaha, and Salmon river subbasins. It also includes 10 artificial propagation programs. There are an additional eight spring/summer Chinook artificial propagation programs within this ESU’s geographical range. However, those programs are not included within this ESU [(NMFS 2019); Figure 3-17 and Table 3-19].

Based on the 2016 status review, NMFS concluded that most of the natural SR spring/summer Chinook populations remain at high overall risk of extinction. The one exception is the Chamberlain Creek population, which has improved to a “maintained” status due to an increased level of abundance (NMFS 2019). NMFS also concluded that most of the populations have increased in abundance since the last status review (Ford 2011) but not to a level that would justify the upgrade of viability ratings. The recent increase in abundance has been attributed, in part, to relatively high ocean survival prior to 2015. However, since that time, ocean conditions have degraded significantly, which has led to poor adult

returns from outmigrant year classes during the period of 2015 to 2017. As such, it is anticipated that adult returns will be negatively impacted through 2019 (NMFS 2019), with returns improving once the cyclical changes in the marine environment switch to more favorable conditions for salmon and steelhead.

Furthermore, (NMFS 2019) concluded that spatial structure ratings for most of the SR spring/summer Chinook populations has remained unchanged or is stable since the last review and that there have been improvements in the abundance/productivity ratings for multiple populations.

Based on their overall findings, (NMFS 2019) concluded the following:

While there have been improvements in the abundance/productivity in multiple populations relative to prior reviews (Ford 2011), those changes have not been sufficient to warrant a change in ESU status (NWFSC (Northwest Fisheries Science Center) 2015). All extant populations (except Chamberlain Creek) face a “high” risk of extinction (NWFSC (Northwest Fisheries Science Center) 2015).

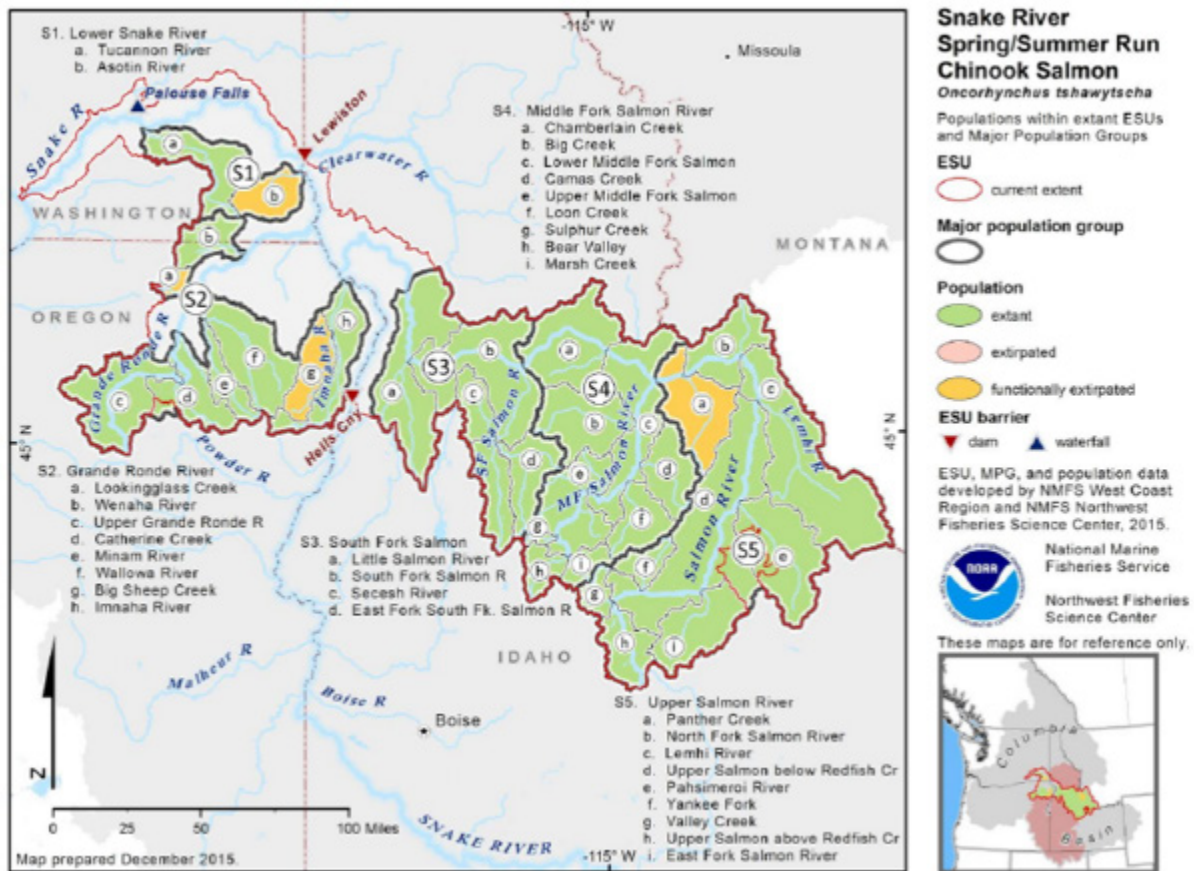


Figure 3-17. SR spring/summer Chinook ESU spawning and rearing areas, illustrating populations and major population groups [reproduced from NMFS (2015)]

Table 3-19. SR spring/summer Chinook MPGs, populations, and overall viability rating [reproduced from NMFS (2019); Table 2.15-2; page 733]

MPG	Populations	Status of Population (overall viability rating)
Natural Production		
Lower Snake River	Tucannon River	High Risk
Grande Ronde/Imnaha Rivers	Wenaha River	High Risk
	Lostine/Wallowa Rivers	High Risk
	Minam River	High Risk
	Catherine Creek	High Risk
	Upper Grande Ronde	High Risk
	Imnaha River	High Risk
South Fork Salmon River	Secesh River	High Risk
	East Fork/Johnson Creek	High Risk
	South Fork Salmon River Mainstem	High Risk
	Little Salmon River	High Risk
Middle Fork Salmon River	Bear Valley Creek	High Risk
	Marsh Creek	High Risk
	Sulphur Creek	High Risk
	Loon Creek	High Risk
	Camas Creek	High Risk
	Big Creek	High Risk
	Chamberlain Creek	Maintained
	Lower Middle Fork Salmon	High Risk
	Upper Middle Fork Salmon	High Risk

Upper Salmon River	Lower Salmon Mainstem River	High Risk
	Lemhi River	High Risk
	Pahsimeroi River	High Risk
	Upper Mainstem Salmon River	High Risk
	East Fork Salmon River	High Risk
	Valley Creek	High Risk
	Yankee Fork Salmon River	High Risk
	North Fork Salmon River	High Risk
Artificial Production		
Hatchery Programs Included in ESU (n = 10)	Tucannon River Sp/Su, Lostine River Sp/Su, Catherine Creek Sp/Su, Lookingglass Hatchery Reintroduction Sp/Su, Upper Grande Ronde Sp/Su, Imnaha River Sp/Su (including Big Sheep Creek Sp/Su, Adult Outplanting program), McCall Hatchery summer, Johnson Creek Artificial Propagation Enhancement summer, Pahsimeroi Hatchery summer, Sawtooth Hatchery spring	NA
Hatchery Programs Not Included in ESU (n = 8)	South Fork Chinook Eggbox spring (formerly Dollar Creek spring), Panther Creek summer, Yankee Fork spring, Rapid River Hatchery spring, Dworshak NFH spring, Kooskia spring, Clearwater Hatchery spring, Nez Perce Tribal Hatchery spring	NA

FACTORS AFFECTING THE STATUS OF SNAKE RIVER SPRING/SUMMER CHINOOK

Within the Snake River tributaries that support the spawning and rearing of SR spring/summer Chinook populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Anthropogenic activities (e.g., agriculture, forestry practices, and human development) have degraded habitat; impaired fish passage; decreased floodplain connectivity, channel structure, function, and complexity; and reduced riparian area, large woody debris recruitment, streamflow, and water quality (NMFS 2019). Additional factors also affect SR spring/summer Chinook status, such as genetic diversity effects from out-of-population hatchery releases, predation, adverse mainstem Columbia River hydropower-related effects, degraded ocean conditions, and harvest (NMFS 2019).

Factors that occur during other life phases of the SR spring/summer Chinook also have profound impacts on the status of the species, including competition with hatchery fish, predation, adverse mainstem Columbia River hydropower-related effects, degraded ocean conditions, and harvest (NMFS 2019).

With a decline in salmonid production, and as a result a decline in spawners within natal streams, nutrients vital to juvenile production have also decreased dramatically. Gresh et al. (2000) estimated that since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only

about 6 to 7 percent of historical levels. They attributed this decline to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. These nutrients are important for salmonid production and, consequently, for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2002).

SR spring/summer Chinook usually spend over a year in freshwater tributaries prior to starting their migration to the ocean. Natural annual climatic conditions significantly affect freshwater spawning and rearing habitat by driving streamflow volume and timing, water temperatures, sediment movement, and other physical features of the aquatic environment. These environmental factors strongly influence egg and alevin survival, overwinter survival, and rearing success (Healey 1991; Quinn 2005).

Widener et al. (2019) compiled estimates of survival for juvenile SR spring/summer Chinook migrating downstream through the Snake and Columbia Rivers. Survival data are empirical estimates for specific geographic segments—by definition, *dam passage survival* is from the forebay to the tailrace of a specific dam or *reach survival*, which is from one dam to another dam (e.g., tailrace of McNary Dam to tailrace of Bonneville Dam). Widener et al. (2019) estimated that reach survival from Lower Granite Dam to Bonneville Dam for natural-origin SR spring/summer Chinook averaged 0.48 from 1999 to 2018. Next, we discuss factors by life stage affecting the status of SR spring/summer Chinook.

Freshwater Spawning, Rearing, and Migration to the CRS

SR spring/summer Chinook use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. 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 good to excellent condition, while in other areas it is minimally to highly degraded as a result of past or present human activities. While many of the habitat modification are relics of past anthropogenic practices, NMFS identified factors limiting viability in the Snake River in tributary areas that continue to influence productivity. Factors limiting this ESU include (1) impaired fish passage, (2) reduced stream complexity and channel structure, (3) excess fine sediment, (4) elevated summer water temperature, (5) diminished streamflow during critical periods, (6) reduced floodplain connectivity and function, and (7) degraded riparian condition (NMFS 2019).

The consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. The ISAB (2015) provided evidence for strong density dependence at current abundance levels for anadromous salmon and steelhead and suggests that habitat capacity has been greatly diminished. Density dependence was observed in most rivers where data have been examined and includes 25 of 27 interior UCR spring-run Chinook and SR spring/summer Chinook populations (ISAB 2015). The ISAB concluded that the 25 populations (where density dependence was observed) exhibited strong density dependence, as shown by a steep decline in productivity at moderate spawning abundances (ISAB 2015).

In a recent assessment of density dependence using a two-stage Gompertz model, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages. They concluded that, because of density dependence during the parr-to-adult stage, a greater number of fish reaching the ocean may not substantially increase the number of adults reaching the spawning grounds. Based on this evidence, the authors concluded the following:

...this suggests that life cycle modeling to date has been overly optimistic about the benefits of survival rate increases in the hydrosystem and elsewhere to improve the viability of salmon populations threatened with high extinction risk.

While the modeling framework of Hinrichsen and Paulsen (2019) was applied to SR spring/summer Chinook, the results are consistent with the 2015 ISAB report and, therefore, it is reasonable to consider UCR steelhead may also experience similar effects of density dependency.

Past and present effects of the existence of CRS dams and operations: SR spring/summer Chinook are not exposed to the CRS facilities or operations during adult holding, spawning, egg incubation, and juvenile rearing and migration within the tributary environment.

Past and present effects of hatcheries: With the desire to maintain harvest, and as spawning, rearing, and migration habitat have degraded and reduced over time, hatcheries were and continue to be used to supplement harvest levels. Hatchery programs largely determine the ratio of hatchery to wild fish that return to the Snake River. Hatchery programs can negatively affect naturally produced populations of salmon and steelhead in a variety of ways, such as competition (for spawning sites and food) and predation effects, disease effects, genetic effects (outbreeding depression), broodstock collection, and facility effects [hatchery-influenced selection; NMFS (2018a)]. Emphasis on hatchery fish also reduce the return of marine nutrients to previously fertile rearing streams that are now used by relatively few naturally produced spring/summer Chinook salmon.

However, benefits may outweigh these risks where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Safety-net or conservation hatchery programs can provide short-term demographic benefits, such as increases in abundance, during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. Conversely, the long-term use of artificial propagation may pose risks to natural productivity and diversity. Even when a hatchery program uses genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s), they may pose a risk to the fitness of the population based on the proportion of natural-origin fish being used as hatchery broodstock and the proportion of hatchery-origin fish spawning in the wild (Lynch and O'Hely 2001; Ford 2002). The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program.

There are currently 18 spring/summer Chinook hatchery programs in the Snake River Basin that release approximately 13 million fish each year. Most of these programs release hatchery fish into rivers with ESA-listed natural-origin SR spring/summer Chinook. Many captive broodstock programs initiated during the 1990s to conserve SR spring/summer Chinook salmon genetic resources have been terminated after the status of these fish improved. These hatcheries have each undergone program-specific consultation and operate consistently with the ESA.

Juvenile SR Spring/Summer Chinook Downstream Migration Through the CRS

The spawning grounds for four of the five MPGs of the SR spring/summer Chinook ESU are in tributary watersheds upstream of Lower Granite Dam. Populations within these MPGs migrate through eight CRS projects to and from the Pacific Ocean. The fifth MPG (lower Snake River) consists of the Tucannon River

population.⁹ The Tucannon River enters the Snake River at RM 62, approximately 8 miles downstream from Little Goose Dam, and that population migrates through a total of six CRS projects as juveniles and adults.

Past and present effects of CRS existence and operations: Through the CRS, juvenile SR spring/summer Chinook salmon have been and continue to be exposed to the effects of both CRS operations and the existence of the CRS dams. Juvenile SR spring/summer Chinook can pass downstream through dams via spillways, surface passage structures, intake screen bypass systems, and turbines. Major modifications have been made to projects within the CRS to improve dam passage survival and achieve the 2008 BiOp performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project. Results from testing at the Lower Columbia and Snake River CRS projects show that the juvenile passage performance standard is being met at most projects in most years for yearling Chinook (Table 3-20). It should be noted that estimates of survival and FPE in the lower Columbia River were reported for yearling Chinook collectively and included both SR spring/summer Chinook, as well as spring Chinook originating from the upper Columbia River. Estimates of survival and FPE at Little Goose and Lower Monumental Dams are for SR spring/summer Chinook, exclusively.

Because survival of fish passing the dams via non-turbine routes is higher than through turbines, passage facilities are designed and operated to increase the likelihood of juvenile fish passage through non-turbine routes. The metric by which this is measured is referred to as FPE. Depending on the location and time of year, greater than 90 percent of yearling Chinook use these non-turbine routes at the four lower Columbia River dams [Bonnevill et al. (2018a); Table 2].

As with the other Snake River ESUs and DPS, SR spring/summer Chinook salmon are collected at Lower Granite, Little Goose, and Lower Monumental dams and transported downstream of Bonneville Dam. The general pattern has been that transportation benefits wild and hatchery SR spring/summer Chinook. The transport results from Little Goose Dam are generally similar, however less benefit is generally observed from transport at Lower Monumental Dam where fewer fish are transported.

Table 3-20. Average fish passage efficiency and dam passage survival estimates for yearling Chinook passing CRS dams [from Bonneville et al. (2018a); based on Table D-1 and D-2]

Dam	Year	FPE	Survival Estimate
Bonneville	2010	---	95.69
Bonneville	2011	---	95.97
The Dalles	2010	---	96.41
The Dalles	2011	---	96.00
John Day	2011	---	96.66; 97.84; 96.76
John Day	2012	92.7	96.73
McNary	2012	96.8	96.16
McNary	2014	91.2	96.10

⁹ This MPG also contains the Asotin River population, which is considered functionally extinct (NWFSC 2015).

Dam	Year	FPE	Survival Estimate
Little Goose	2012	96.3	98.22
Lower Monumental	2012	94.8	98.68

Past modifications of the dams to improve fish passage include the installation of surface passage systems, improved turbine designs, and upgrades of screened bypass systems to improve how and where fish are returned to the river downstream from dams, as well as new spill operations tailored to the unique structural configuration of each dam (Bonneville et al. 2018a). A summary of those improvements is provided in Appendix A of Bonneville et al. (2018a) and is incorporated by reference here. However, the actions that have benefitted SR spring/summer Chinook include the following:

- Minimizing winter drafts of the large upper basin storage reservoirs (for flood risk management and power generation) to save water for augmenting spring flows during the peak juvenile passage period (water quantity).
- Employ JBSs and surface passage structures and provide spill at the run-of-river dams to divert smolts away from turbine units and reduce potential delay in the forebays and minimize predation (safe passage).
- Install replacement turbines with biologically based designs for safer fish passage than the case for the original units.
- Reduce TDG through multiple actions and plans.
- Manage avian and fish predators through multiple actions and plans.

For SR spring/summer Chinook (hatchery and wild combined, cohort years 1997 to 2007), reach survival from Lower Granite Dam to McNary Dam averaged 72.4 percent. From 2008 to 2018, reach survival averaged 76.2 percent. Survival for juvenile Chinook yearlings averaged 70.3 percent for years 1999 to 2007 from McNary to Bonneville Dam and 68.8 for the same reach from 2008 to 2018. The reduced survival rates in the lower Columbia River could have been influenced by increased predation by Caspian terns displaced from Crescent Islands to Blalock Island in the John Day Dam Pool [Roby et al. (2016) as cited in NMFS (2019)]. Overall, yearling Chinook survival from Lower Granite Dam to Bonneville Dam for years 1999 to 2018 averaged 52.1 percent (Widener et al. 2019).

In addition, elevated TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can get forced into solution when water passes over the spillway at a mainstem dam, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019). Because SR juvenile spring/summer Chinook are susceptible to GBT, they benefit from the gas abatement structures.

Past and present effects of predator management: Survival of SR juvenile spring/summer Chinook is reduced by avian and native and non-native fish predators that inhabit the mainstem Snake and Columbia Rivers. The 2008 FCRPS BiOp required that the Action Agencies implement multiple predation control measures to increase survival of juvenile salmonids through effective monitoring, hazing, and

deterrents at each project. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019).

Juvenile SR Spring/Summer Chinook Estuary Migration and Rearing, Including the Plume

The estuary provides important habitat for SR spring/summer Chinook populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also impacted estuary ecosystems. For a more detailed discussion of estuary and plume conditions, see (NMFS 2019). All these conditions are part of the environmental baseline.

Past and present effects of CRS existence and operations: While there are no CRS facilities in the estuary (defined as Bonneville Dam to the ocean), past CRS management affected the timing and volume of flows, as well as temperature, sediment load, and TDG levels in this area. The effects of CRS management actions generally decrease as distance from Bonneville Dam increases and estuary hydrodynamics become less fluvially influenced. In particular, flow regulation and reduced sediment recruitment caused by the CRS have likely negatively affected habitat forming processes in the estuary, habitats which support the juvenile life stage of all Columbia River Basin anadromous fish populations.

Estuarine habitat is important for out-migrating juvenile SR spring/summer Chinook. To help maintain and improve the overall status of salmon and steelhead in the Columbia River Basin, the Action Agencies actively work to restore and conserve habitat in the Columbia River estuary through the CEERP. These restoration actions affect salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit of estuary restoration is that wetland food production supports foraging and growth within the wetland [Johnson et al. (2018) as cited in NMFS (2019)]. Prey items (primarily chironomid insects and corophiid amphipods [PNL/NMFS (2018) as cited in NMFS (2019)]) produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest 5-year review of the CEERP (Johnson et al. 2018), have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity below Bonneville Dam [Johnson et al. (2018) as cited in NMFS (2019)]. In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past and present effects of predation management: A variety of avian species (especially Caspian terns and double-crested cormorants), have historically been a major source of predation on juvenile salmonids in the estuary. While avian predators continue to prey upon juvenile salmonids, including SR spring/summer Chinook, predation rates have declined due to a variety of management efforts.

Based on PIT-tag recoveries from East Sand Island, the mean annual tern and cormorant predation rates for SR spring/summer Chinook were about 4.8 and 5.2 percent, respectively, prior to efforts to manage the size of these colonies [Evans et al. (2018) as cited in NMFS (2019)]. In order to reduce avian predation, the Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans. Average predation rates on SR spring/summer Chinook salmon have decreased to 1.5 percent for terns nesting on East Sand Island in the lower estuary. The efforts to reduce avian predation are discussed in detail within the 2019 BiOp and are incorporated by reference here (NMFS 2019).

Ocean Rearing

The length of ocean residence for SR spring/summer Chinook is typically 2 to 3 years, and during marine residence, this ESU exhibits extensive migrations (NMFS 2019). Since about 2014, poor ocean conditions have contributed to declines in ocean survival and associated adult returns. In the 2019 BiOp, NMFS provides a detailed discussion on ocean conditions, factors that affect the ocean environment, and impacts to SR spring/summer Chinook. That information is incorporated here by reference; a brief summary follows.

Factors that influence ocean conditions are also likely to affect survival of SR spring/summer Chinook. The consequences of climate change will likely include increased water temperatures, more severe El Niño events, worsened ocean acidification, and major alterations in the northeast Pacific Ocean marine ecosystem associated with the Pacific Decadal Oscillation (NMFS 2019). These factors will affect SR spring/summer Chinook survival either directly or indirectly because of their deleterious impacts on marine food webs.

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in distribution of aquatic marine organisms. Many species that typically occur in more southerly waters moved northward from southern California to Alaska in the unusually warm water during 2014 and 2015, which was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Pearcy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt marine ecosystems in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean, and past CRS operations have had no direct effect on this ESU during ocean residence. Welch et al. (2018) concluded that marine survival of west coast Chinook and steelhead populations has collapsed over the last half century for most regions of the West Coast. Based on their review of annual survival estimates for Chinook and steelhead, they concluded the following:

We found that marine survival collapsed over the past half century by a factor of at least 4–5-fold to similar low levels (~1%) for most regions of the West Coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Another factor that should be considered is delayed or latent mortality. Delayed mortality is a term for harm caused when an animal survives one event or circumstance but incurs damage that only shows up later and may be expressed as illness or death. With Columbia River Basin salmon and steelhead, the term is commonly applied in situations such as barging or dam passage of salmon or steelhead smolts. The term “latent mortality” is generally used more specifically to apply to the effects of dam passage. While most or all of the fish might survive the act of barging or migrating in-river past the dam, the delayed mortality hypothesis holds that, as a result of passing a dam, a smolt is less healthy than it would be otherwise and, therefore, less likely to survive in the ocean and return as an adult.

The ISAB (2012) concluded, after reviewing various studies, that their analyses demonstrated that fish bypass systems are associated with some latent mortality, but the factors responsible for latent mortality remain poorly understood and are inadequately evaluated; further,

The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis).

Past and present effects of harvest: Harvest of spring/summer Chinook in the ocean is rare (NMFS 2019). Based on the recovery of Coded Wire Tags (CWTs), NMFS has concluded that ocean mortality associated with fisheries is very low, and for practical purposes is assumed to be zero. NMFS hypothesizes that mortality is low since SR spring/summer Chinook are not present within nearshore areas where ocean salmon fisheries traditionally occur (NMFS 2019).

Adult SR Spring/Summer Chinook Migration to Bonneville Dam

Adult spring/summer Chinook migrating upstream after ocean residence typically do not feed within the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume, and a migratory corridor free of obstructions to access spawning areas (NMFS 2019). Populations of SR spring/summer Chinook enter the Columbia River estuary and pass over Bonneville Dam from April through June, with the peak migration typically observed in mid-May (NMFS 2019; Wargo Rub et al. 2019).

For upstream migrating SR spring/summer Chinook, the primary factor affecting survival to Bonneville Dam is pinniped predation. Estimates of pinniped predation downstream of the Bonneville Dam tailrace are not available, specifically for adult spring/summer Chinook. However, salmonid consumption by California sea lions, Stellar sea lions and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). Wargo Rub et al. (2019), as cited in NMFS (2019), estimated that up to 50 percent of the mortality from pinnipeds of adult spring-run Chinook salmon destined for tributaries above Bonneville Dam occurred within the 10-mile reach just below the dam. Tidwell et al. (2018), as cited in NMFS (2019), reports that an estimated 4,951 adult spring Chinook salmon (all ESUs) were consumed by both pinniped species in 2017, which equates to 4.5 percent of the adult spring Chinook salmon that passed. Consumption rates of spring Chinook salmon in the last 3 years (2015–2017) have ranged from 4.3 to 5.9 percent and are the highest consumption rates since monitoring began in 2002.

Past and present effects of CRS dams and operations: There are no CRS dams that impede upstream migration in the Columbia River estuary to Bonneville Dam. As previously mentioned, adult SR spring/summer Chinook enter the Columbia River from April through June, with the peak migration typically occurring mid-May. During that period, the Action Agencies are required to spill water over the CRS dams to increase survival of juvenile fish migrating downstream. As such, adults may be exposed to higher levels of TDG, which may influence their migration behavior or increase their chances of GBT (NMFS 2019). However, adults migrate at depths that reduce the effective exposure to TDG, and TDG levels are mitigated, to some extent, downstream from Bonneville Dam due to gas dissipation and to mixing of water with lower TDG levels from tributaries to the estuary.

Past and present effects of harvest: 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. 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 Chinook salmon occurs in spring- and summer-season fisheries in the mainstem Columbia River that target harvestable hatchery- and natural-origin stocks. Allowable harvest depends on the total (hatchery- and 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 Chinook salmon. The allowable harvest rate (on natural-origin fish), including treaty and non-treaty Columbia River fisheries combined, may range from 5.5 to 17 percent of the predicted Columbia River return per year. The average annual harvest rate on these fish from 2008–2017 under U.S. v. Oregon jurisdiction averaged 12.1 percent [NMFS (2018b) as cited in NMFS (2019)].

Adult SR Spring/Summer Chinook Migration Through CRS Dams

Most SR spring/summer Chinook populations will migrate upstream through all eight Lower Columbia and Snake River CRS projects on their way to natal spawning areas. The single exception is the Tucannon population, which migrates upstream of six CRS projects. During upstream migration, these fish experience a variety of factors affecting the adult migration life stage, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish [NMFS (2008b) as cited in NMFS (2019)].

Past and present effects of CRS existence and operations: Under typical conditions, after accounting for reported harvest rates and expected stray rates, adult SR spring/summer Chinook have relatively high conversion rates¹⁰ passing the Lower Columbia and Snake River CRS dams (six CRS projects for the Tucannon population (NMFS 2019). Survival of adult SR spring/summer Chinook from Bonneville to McNary Dam averaged 88.7 percent over a 10-year period (range of 82.8 to 100.0 percent). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 96.1 percent per project. Based on the same dataset, the

¹⁰ Conversion rates are simply the percentage of adult salmonids passing an upstream dam that passed a downstream dam ($\frac{\# \text{ passing}_{\text{upstream dam}}}{\# \text{ passing}_{\text{downstream dam}}}$). Conversion rate is used as a surrogate for survival, but other factors (than mortality) may affect the number of adult fish passing the upstream dam (e.g., tag not detected), so a conversion rate is not specifically an accurate measure of survival.

minimum survival estimate for the Bonneville to Lower Granite Dam reach has been estimated to be 84.3 percent (range of 77.2 to 93.5 percent). Based on this estimate of reach survival, per project survival averages 97.6 percent (NMFS 2019). Because of these relatively high survival estimates, NMFS has concluded that upstream passage conditions for adult SR spring/summer Chinook are not substantially impaired as fish migrate through the lower Columbia and Snake Rivers (NMFS 2019).

These estimates of minimum survival also account for impacts associated with fallback at the CRS projects, such as direct and indirect mortality associated with the fallback event, delay, straying, etc. Results from radio telemetry research for the years of 1995 to 2003 show that, after fallback, re-ascension rates are highest at downstream dams, 19 percent of spring/summer Chinook fall back at least once, fallback rates are correlated to flow at most Columbia and Snake River dams, and fish that fall back are significantly less likely to reach spawning grounds relative to fish that never fall back [(Keefer et al. 2005) as cited in NMFS (2019)]. PIT-tag detections at Bonneville Dam for the period of 2006 to 2011 show that 9.6 percent of spring/summer Chinook that fall back at that project subsequently re-ascend that project's fishways [DART (2019) as cited in NMFS (2019)].

Past and present effects of predator management: As discussed previously, the presence of pinniped predators has increased within the Bonneville Dam tailrace in recent years, with occasional pinniped observations in the Bonneville reservoir (NMFS 2019). To restrict entry of pinnipeds into the ladder systems at Bonneville Dam, the Corps constructed structures to physically exclude pinniped entry into fishways, while allowing upstream migration of adult salmonids. These structures have been installed at all eight fishway entrances at Bonneville Dam (NMFS 2019).

In addition, water is released from Dworshak Dam in the summer to reduce temperatures in the Snake River to reduce potential negative effects of increased water temperature on upstream migrating adult salmon and steelhead. Operators manage the Dworshak project so temperatures do not exceed 68°F at the tailrace of Lower Granite Dam. These releases substantially cool the lower Clearwater River and Lower Granite Reservoir. These ongoing cool-water releases have improved late summer migration conditions for adult fall Chinook salmon in the Snake River (compared to historical conditions).

Past and present effects of harvest: 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. The allowable harvest rate (on natural-origin fish), including treaty and non-treaty Columbia River fisheries combined, may range from 5.5 to 17 percent of the predicted Columbia River return per year. The average annual harvest rate on these fish from 2008–2017 under U.S. v. Oregon jurisdiction averaged 12.1 percent [U.S. v. Oregon (2018) as cited in NMFS (2019)].

Salmon and steelhead fishing also occurs in the Snake River mainstem and its tributaries in the states of Washington, Oregon, and Idaho. Fisheries occurring in the lower Snake River (downstream of the Washington/Idaho border to the confluence with the mainstem Columbia River) during the spring are under U.S. v. Oregon jurisdiction 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 (FIP). These plans are developed based on sliding scales, based on the forecasted abundance of returning adult salmon and steelhead, which is modified in-season, if need be. Natural-origin fish are rarely targeted in these fisheries. Whether a particular natural-origin population is impacted depends on their run timing (whether they intermix with targeted fish or not) and if there is a

hatchery component of the population, which may affect natural-origin fish when they are caught and released. Based on these criteria, harvest rates on individual populations may vary between 0 and 42 percent (NMFS 2019).

Adult SR Spring/Summer Chinook Migration Upstream of the CRS to the Spawning Areas

Within the Snake River tributaries that support the spawning and rearing of SR spring/summer Chinook populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (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 streamflow during critical periods, (6) reduced floodplain connectivity and function, and (7) degraded riparian condition (NMFS 2019).

Low flows and high summer temperatures in tributary habitats can effectively create temporary migration barriers that reduce access to spawning habitat until conditions improve. These impacts to water quality in tributary habitat can affect the run timing and survival to natal spawning areas for adult SR spring/summer Chinook.

Past and present effects of harvest: Salmon and steelhead fishing also occurs in the Snake River mainstem tributaries in the states of Washington, Oregon, and Idaho. For fisheries operating upstream in Idaho, co-managers currently develop and submit to NMFS yearly FIP. Whether a particular natural-origin population is impacted depends on their run timing (whether they intermix with targeted fish or not) and if there is a hatchery component of the population, which may affect natural-origin fish when they are caught and released. The allowable mortality of natural-origin spring/summer Chinook salmon is based on the Minimum Abundance Thresholds (MAT) that have been identified for recovery purposes. A sliding scale is used based on the forecasted aggregate adult run size of natural populations as a percentage of the pooled MAT. Based on this sliding scale, harvest rates on individual populations may vary between 0 (when the predicted run size is less than 30 percent of MAT) to 42 percent (when the predicted run size is greater than 108 percent of MAT) (NMFS 2019).

STATUS OF CRITICAL HABITAT

In this section of the biological assessment, the status of critical habitat is reviewed for SR spring/summer Chinook and factors affecting the status of critical habitat are discussed. Critical habitat includes the stream channels within designated stream reaches and, to an extent, is defined by the ordinary high-water mark (33 CFR §319.11). The PBFs of critical habitat that are essential to the conservation of SR spring/summer Chinook have been identified and include freshwater spawning and rearing areas, juvenile and adult migration corridors, and estuarine areas (Table 3-21) (NMFS 2019). The PBFs of critical habitat and climate change effects are presented in this section.

Critical habitat for the SR spring/summer Chinook ESU was originally designated on December 28, 1993 (58 FR 68543), and was most recently updated on October 25, 1999 (64 FR 57399). Critical habitat for SR spring/summer Chinook was designated within the Interior Columbia Recovery Domain, which includes

the Snake River Basin, as well as the Columbia River estuary, which is within the lower Columbia River Estuary Recovery Domain.

Table 3-21. Physical and biological features and components and principal factors affecting the environmental baseline of critical habitat designated for SR spring/summer Chinook [based on NMFS (2019); Table 2.15-4]

PBFs	Components of the PBFs	Principal Factors affecting Environmental Baseline Condition of the PBFs
Freshwater spawning and juvenile rearing areas	<p>Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility</p> <p>Water quality and forage supporting juvenile development</p> <p>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</p> <p>Suitable conditions and substrate supporting spawning, incubation, and larval development</p>	<p>Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage)</p> <p>Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage)</p> <p>Diminished streamflow (degraded water quantity, elevated temperatures, loss of juvenile and adult mobility)</p> <p>Impaired fish passage (obstructions, water withdrawals)</p> <p>Excess fine sediment in spawning gravel (degraded water quantity)</p> <p>Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation)</p>
Adult and juvenile freshwater migration corridors	<p>Free of obstruction and excessive predation (safe passage)</p> <p>Adequate forage supporting juvenile development</p> <p>Adequate water quality, quantity, and velocity</p> <p>Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels</p>	<p>Delay and mortality of adults (at up to eight mainstem dams)</p> <p>Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human built structures used by terns and cormorants for nesting)</p> <p>Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage) and the presence of toxic contaminants (reduced water quality and forage).</p>

SR spring/summer Chinook migrate upstream through the Columbia River estuary and pass over Bonneville Dam typically during the April to June period, with peak migration in mid-May (NMFS 2019; Wargo Rub et al. 2019). During their freshwater migration, adult spring/summer Chinook require habitat that includes cool water 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 2019).

All spring/summer Chinook spawn in gravel and cobble substrates that are largely free of fine sediments. Developing eggs require cool, clean, and well-oxygenated waters for proper development. SR

spring/summer Chinook usually spend more than 1 year in freshwater tributaries prior to starting their migration to the ocean. During their freshwater residence, juvenile salmonids need abundant food sources and instream cover to protect them from predators. Juvenile fish cover may include undercut banks, overhanging vegetation, logs and root wads, and large substrate (NMFS 2019). Off-channel habitat, side channels, and other low stream velocity areas provide refuge during high flow events. Cool waters offered by springs, seeps, and deep pools offer refuge when stream temperature increase during the summer. Interstices offered by large substrate allow juveniles to seek refuge during the winter.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of SR spring/summer Chinook. The quality of tributary habitat for SR spring/summer Chinook varies substantially throughout the Snake River region, with some spawning and rearing habitat in near-pristine condition, while other areas are minimally to highly degraded due to past human activities (NMFS 2019). Habitat throughout the interior Columbia River Basin tributaries has been degraded by numerous human activities, including 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, timber harvest, mining, and urbanization [Lee et al. (1997) as cited in NMFS (2019)]. These activities have led to factors that limit the viability of SR spring/summer Chinook. These factors include (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 streamflow during critical periods, (6) reduced floodplain connectivity and function, and (7) degraded riparian condition (NMFS 2019).

Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel instability are common symptoms of ecosystem decline in areas of critical habitat. Lack of adequate summer streamflows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas of the interior Columbia River Basin. Large-scale habitat assessments in the interior Columbia River Basin indicate that, in watersheds managed for natural resources extraction, the number of large pools has decreased substantially since the early 1900s, resulting in a significant decrease in habitat diversity [McIntosh et al. (1994) as cited in NMFS (2019)]. Since 2007, to address these issues and to mitigate impacts associated with the operation of the CRS, the Action Agencies, in cooperation with private, local, state, tribal, and federal entities, have implemented a variety of tributary habitat restoration actions throughout the Snake River region to benefit SR spring/summer Chinook. Those restoration actions are summarized in Table 3-22.

In the 2019 BiOp, (NMFS 2019) said,

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have 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.

Table 3-22. Tributary habitat improvement metrics: SR spring/summer Chinook, 2007–2015
[Reproduced from NMFS (2019); Table 2.15-10]

Action Type ^a	Amount Completed
Acre-feet per year of water protected (by efficiency improvements and water purchase/lease projects)	58,854.3
Acres protected (by land purchases or conservation easements)	2,203.5
Acres treated (to improve riparian habitat, such as planting native vegetation or controlling noxious weeds)	5,095.5
Miles of enhanced or newly accessible habitat (by providing passage or removing barriers)	980.0
Miles of improved stream complexity (by adding wood or boulder structures or reconnecting existing habitat, such as side channels)	142.1
Miles protected (by land purchases or conservation easements)	140.6
Screens installed or addressed (for compliance with criteria or by elimination/consolidation of diversions)	69

^a Several of these categories (i.e., acres protected, acres treated, miles of enhanced stream complexity and miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

The consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. The ISAB (2015) provided evidence for strong density dependence at current abundance levels for anadromous salmon and steelhead and suggested that habitat capacity has been greatly diminished. Density dependence was observed in most rivers where data have been examined and includes 25 of 27 interior UCR spring-run Chinook and SR spring/summer Chinook populations (ISAB 2015). The ISAB concluded that the 25 populations (where density dependence was observed) exhibited strong density dependence, as shown by a steep decline in productivity at moderate spawning abundances (ISAB 2015).

In an assessment of density dependence using a two-stage Gompertz model and applying it to SR spring/summer Chinook, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages and concluded that, because of density dependence during the parr-to-adult stage, a greater number of fish reaching the ocean may not substantially increase the number of adults reaching the spawning grounds.

Key recommendation from ISAB (2015) included (1) account for density effects when planning and evaluating habitat restoration actions, (2) establish biological spawning escapement objectives that account for density dependence, (3) balance hatchery supplementation with the Columbia River Basin's capacity to support existing natural populations by considering density effects on the abundance and productivity of natural origin salmon and steelhead, and (4) improve capabilities to evaluate density dependent growth, dispersal, and survival by addressing primary data gaps.

Freshwater Migration Corridor

The freshwater migration corridor extends from the spawning and rearing areas in the Snake River subbasins downstream to the Columbia River plume. Migration corridors are considered essential to the conservation of SR spring/summer Chinook. Human activities that have affected habitat in tributary reaches have already been discussed and contribute to the quality and quantity of water downstream and within the migration corridor of the Columbia River. Tributary habitat actions already implemented support all MPGs of SR spring/summer Chinook and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, removing barriers to spawning and rearing habitat, and other actions targeted toward addressing limiting factors (NMFS 2019). No CRS projects exist in the freshwater tributary corridors, and SR spring/summer Chinook are not exposed to any CRS operations until they reach the mainstem Snake River reservoir created by the first dam they encounter.

The quality of designated critical habitat within the Snake River and Columbia River migration corridor is a function of the cumulative impacts of upstream actions, including development along the corridor, dam existence and operations, and CRS management that affects both juvenile and adult SR spring/summer Chinook. All these factors combine to affect critical habitat in the mainstem and influence the migration corridor. Habitat within the mainstem Columbia River has been substantially altered by a variety of factors, including basin-wide water management, the existence and on-going operations of CRS projects, and other human-related activities that have degraded water quality and habitat (NMFS 2019). Within the 2019 BiOp, NMFS describes those factors affecting the behavior and survival of SR spring/summer Chinook through the CRS, and that information is incorporated here by reference (NMFS 2019). However, the following briefly summarizes that information.

Mainstem dams and dam operations can affect stream temperature, streamflow, gas supersaturation levels, and river habitats. Both the Snake and Columbia Rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Because the temperature regime has been modified, resulting in warmer late-summer/fall water temperatures, it potentially affects juvenile and adult salmonids, as well as fish community structure. Warmer stream temperatures may influence predation rates on juvenile fish by predatory fish species. Juvenile fish may also be affected when water is spilled from hydroelectric facilities that increase gas supersaturation and may lead to GBT in fish. All projects create impoundments that affect riverine habitats and can affect travel times, which in turn, may increase juvenile fish exposure to both native and non-native predators. Some passage routes through dams may decrease juvenile fish survival (e.g., turbines) compared to spill bays and surface passage routes that are operated to increase overall juvenile passage survival. The processes, general effects, and mitigation of CRS mainstem dams and dam operations on the functioning of critical habitat are shown in Table 3-23.

Since 2008, when modifications to the physical and operational CRS system were implemented based on the 2008 BiOp, survival of juvenile SR spring/summer Chinook and adult migrants has improved substantially. Under typical conditions, after accounting for reported harvest rates and expected stray rates, adult SR spring/summer Chinook have relatively high conversion rates passing the Lower Columbia and Snake River CRS dams (NMFS 2019). Survival for adult SR spring/summer Chinook from Bonneville to McNary dams averaged 88.7 percent over a 10-year period (range of 82.8 to

100.0 percent). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 96.1 percent per project. Based on the same dataset, the minimum survival estimate for the Bonneville to Lower Granite Dam reach has been estimated to be 84.3 percent (range of 77.2 to 93.5 percent). Based on this estimate of reach survival, per project survival averages 97.6 percent (NMFS 2019).

Table 3-23. The processes and effects of the CRS dams and dam operations, and mitigation efforts to address the effects

Process	Effect	Mitigation
Passage at dams	Reduced juvenile survival at dams	Surface passage, increased proportion of spill, flow augmentation, TDG management, bypasses, and fish-friendly turbines
Water storage operations	Altered water quantity and seasonal timing	Flow augmentation
Solar radiation/reduction in mainstem stream velocity	Altered temperature, both in the reaches below the large mainstem storage projects and migration corridors	The dams result in water temperatures that are slightly better (cooler) during the spring migration
Spill	Increased TDG	System-wide TDG management
Modification of habitat	Altered food webs, including both predators and prey	Avian management, fish bypass outfall placement (away from known predator concentrations), and pikeminnow removal (management)

Estuarine and Nearshore Ocean Areas

Critical habitat has been designated for SR spring/summer Chinook in the Columbia River estuary (NMFS 2019). NMFS has defined the estuary to include the tidally influenced portion of the Columbia River (i.e., from Bonneville Dam [RM 146] to the mouth of the Columbia River), including the lower portions of tributaries influenced by tidal action. As such, the lower 26 miles of the Willamette River are also included within the estuary domain.

(NMFS 2019) considers a functioning estuary to be essential to the conservation of SR spring/summer Chinook. NMFS identified the PBFs for SR spring/summer Chinook in estuaries to include areas free of obstruction with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater 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.

(NMFS 2019) identified degraded habitat conditions in the estuary as a limiting factor for SR spring/summer Chinook. Historically, the Columbia River estuary was more dynamic than it is today. Multiple channels, extensive wetlands, sandbars, and shallow areas, especially in the downstream 50 river miles, were influenced by winter and spring floods, low flows in late summer, large woody debris, and high sediment loads (NMFS 2019). As reported by (NMFS 2019), the current conditions of the Columbia River estuary have changed as a result of many factors, including dredging to deepen and maintain the Federal Navigation Channel and construction of jetties and pile-dike fields to stabilize and

concentrate river flow. Causeways have been constructed across waterways. As noted by (NMFS 2019), the mouth of the Columbia River was historically about 4 miles wide but has decreased to about 2 miles wide, and the depth has increased at the Columbia River channel at the bar from less than 20 feet to more than 55 feet.

In particular, (NMFS 2019) reported a dramatic decrease in wetland areas in the Columbia River estuary. More than 50 percent of the marshes and spruce swamps have been converted to industrial, transportation, recreational, agricultural, or urban areas, with more than 3,000 acres converted since 1948 (NMFS 2019). In the upper reaches of the estuary, many wetlands on the floodplain have been converted to industrial and agricultural lands after levees and dikes were constructed. As reported by (NMFS 2019), 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost since the late 1800s. Those wetlands support salmonid food webs, both in shallow water and in the mainstem.

Changes in streamflow and sediment delivery have also affected critical habitat in the Columbia River estuary. NMFS reports that water storage and release patterns from reservoirs upstream have changed the seasonal pattern and volume of discharge within the Columbia River estuary (NMFS 2019). Discharge has increased in the winter and peak spring/summer floods have been reduced. (NMFS 2019) also reported that model studies indicate that combined human activities in the Columbia River Basin have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine-sediment transport by 50 percent or more. The significance of changes in sediment delivery to UCR steelhead is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean and subyearlings that may spend months in the estuary [Johnson et al. (2018); PNNL/NMFS (2018); and Weitkamp (2018) as cited in NMFS (2019)].

In terms of critical habitat, there are no CRS-related barriers to migration in the estuary, and there is no evidence that flows are insufficient for migration.

EFFECTS OF THE ACTION ON SR SPRING/SUMMER CHINOOK SALMON

The effects of the existence of the dam and reservoir system, and past operations, are part of the environmental baseline and are not considered effects of the Proposed Action. The main effects on SR spring/summer Chinook salmon of continuing to operate and maintain the CRS involve lessening the negative effects of baseline passage impediments and advancing safe downstream and upstream passage through the CRS mainstem lower Columbia River dams. Effects of the Proposed Action would include, for example, any potential delayed/latent mortality hypothesized to occur as a result of how operating the dams affects juvenile salmon and steelhead passage at the dams; changes in juvenile fish travel time as a result of operations; and potential exposure to elevated TDG as a result of spill. Improving juvenile and adult migration survival has been the focus of structural and operational actions under past BiOps, the benefits of which have been documented (Corps et al. 2017a; Bonneville et al. 2018a). These already-completed actions are part of the baseline condition and will continue to provide benefits in the future. The effects of the Proposed Action on the SR spring/summer Chinook ESU and its critical habitat are described by life stage next.

Freshwater Spawning, Rearing, and Migration to the CRS

In their spawning and rearing areas, SR spring/summer Chinook are not exposed to the effects of operation of the Proposed Action, because no operations (e.g., flood risk management, irrigation, power generation) occur in these areas. Because of this lack of exposure, there will be no direct effects from CRS management to individual fish in these areas.

Some individual fish of this ESU are exposed to habitat improvements through the Tributary Habitat Improvement Program component of the Proposed Action. SR spring/summer Chinook salmon will benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that will result from the tributary habitat actions. Adverse effects to individuals from construction of habitat improvement actions are mitigated through compliance with BiOps for Tributary Habitat Improvement Program (NMFS 2013; USFWS 2013). Activities in freshwater spawning, rearing, and migration habitats include work to improve streamflow protection and enhancement, habitat access, stream complexity, riparian habitat, screening to reduce entrainment, and more. These actions will continue to improve habitat condition over the baseline condition.

Juvenile SR Spring/Summer Chinook Downstream Migration Through the CRS

Juvenile SR spring/summer Chinook salmon are not exposed to the effects of CRS operations until they reach the mainstem Snake River and as they pass through CRS dams. In this migration corridor, juvenile SR spring/summer Chinook salmon will continue to experience the deleterious impacts of a degraded environmental baseline, including existence of the dams and associated cumulative effects.

Through previous actions, operations and structures at individual CRS mainstem dams have been modified and adapted for the specific conditions of each dam to reduce turbine passage, decrease forebay and tailrace residence times, and improve overall dam passage survival (Corps et al. 2017b).

In general, the Proposed Action will continue operations and implement actions to minimize negative effects from both baseline conditions and the Proposed Action. Measures presently being implemented and proposed to continue include flow augmentation, measures to direct juveniles away from turbines (e.g., voluntary spill, surface passage structures, and intake bypass systems), fish-friendly turbines, and predator management.

Changes in the Proposed Action compared to past operations include a flex spill operation and changed implementation of summer spill. Because juvenile SR spring/summer Chinook salmon do not migrate during the summer, any changes in summer spill will not affect this ESU. Changes to spring spill could result in an increased juvenile passage survival for SR spring/summer Chinook salmon that are passing through the CRS and decrease latent mortality.

The indicators (also termed factors) used below to assess the effects of the Proposed Action on juvenile SR spring/summer Chinook migration through the CRS are categorized as operational (modeling metrics, survival at CRS dams, mainstem CR fish travel time, powerhouse passage proportion, TDG, temperature, turbidity, and predation) and non-operational (predation management and fish status and trend monitoring). Using these indicators, analyses of effects to UCR steelhead during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Modeling Results

The EIS COMPASS and CSS modeling results support the qualitative expectations that the Proposed Action survival rates from the lower Snake River to below Bonneville Dam would increase, though the magnitudes varied from less than one percentage point to almost six percentage points, depending on the model (Table 3-24). Travel time would decrease about 8 to 14 percent. The most notable changes would be about an 80 percent reduction in powerhouse encounter rates, a major reduction in proportion of fish transported, and TDG exposure of almost 120% average on a smolt's migration.

The modeled change in SARs and abundance depends on model assumptions and drivers. NWFSC LCMs predicted a decrease in SARs and abundance if latent mortality were to be the same as the 2016 operation. If decreased powerhouse encounters were to decrease latent mortality and, therefore, increase ocean survival, the SARs and abundance would show an increase. CSS predicts SARs and abundance would both show major increases.

Table 3-24. Model metrics for Juvenile SR spring/summer Chinook salmon

Metric (Model)	NAA (2016 Ops)	The preferred alternative		MO4		Range
		Value	Change from NAA	Value	Change from NAA	
Juvenile Survival (COMPASS)	50.4%	51.0%	1.2%	50.7%	0.6%	0.6%
Juvenile Survival (CSS)	57.6%	58.3%	1.2%	63.5%	10.2%	5.9%
Juvenile Travel Time (COMPASS)	17.7 days	17.4 days	-1.7%	16.2 days	-8.5%	1.5
Juvenile Travel Time (CSS)	15.8 days	15.5 days	-1.9%	13.6 days	-13.9%	2.2
Transported (COMPASS)	38.5%	37.8%	-1.8%	7.3%	-81.0%	31.2%
Transported (CSS)	19.2%	26.5%	38.0%	6.9%	-64.1%	19.6%
Transport: In River Benefit Ratio (CSS)	0.86	0.68	-20.9%	0.56	-34.9%	0.3
Powerhouse Passages (COMPASS)	2.25	1.88	-16.4%	0.49	-78.2%	1.76
Powerhouse Passages (CSS)	2.15	1.74	-19.1%	0.34	-84.2%	1.81
TDG Average Exposure (TDG Tool)	114.6%	115.1%	0.4%	119.7%	4.5%	5.1%
TDG-Related Juvenile Survival	97.9%	97.5%	-0.4%	81.9%	-16.3%	16.0%

Survival at CRS Dams

Survival of juvenile SR spring/summer Chinook once they enter the Snake and Columbia Rivers is influenced by a suite of factors—passage conditions at mainstem dams, flow conditions, water quality (e.g., temperature, TDG), predators, etc. Survival studies show, with few exceptions, that measures implemented through the previous CRS BiOps, and continued into the current Proposed Action, have

performed as desired, achieving or very close to achieving the 2008 BiOp juvenile dam passage survival objective of 96 percent for juvenile spring/summer Chinook salmon (NMFS 2017e).

We anticipate that increases in spillway passage associated with spring flexible spill may result in increased reach survival. The COMPASS model relies on juvenile route survival estimates and predicts the increase in spill (flexible spill up to 125 percent TDG) will result in an increase in juvenile SR spring/summer Chinook salmon reach survival passing eight CRS dams. It is important to note that since higher spill levels result in unbalanced energy and 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. However, most predictions are for increased survival.

For SR spring/summer Chinook (hatchery and wild combined) cohort years 1997 to 2007, reach survival from Lower Granite Dam to McNary Dam averaged 72.4 percent. From 2008 to 2018, survival averaged 76.2 percent. Survival for yearling Chinook averaged 70.3 percent for years 1999 to 2007 from McNary to Bonneville Dam and 68.8 for the same reach from 2008 to 2018. The reduced survival rates in the lower Columbia River, as shown in the comparison of time periods (starting in about 2015), were likely influenced by increased predation by Caspian terns displaced from Crescent Islands to Blalock Island in the John Day Dam Pool [Roby et al. (2016) as cited in NMFS (2019)]. Overall, survival of yearling Chinook salmon from Lower Granite Dam to Bonneville Dam for 1999 to 2018 averaged 52.1 percent (Widener et al. 2019). Implementation of the Proposed Action is expected to maintain or improve survival of SR spring/summer Chinook salmon migrating through the system and reduce any latent/delayed mortality after they pass Bonneville Dam. The COMPASS model estimates that survival could increase juvenile survival from Lower Granite Dam to Bonneville dam by less than one percent, while CSS estimates survival at 5.9 percentage points higher than the 2016 operation.

Transportation

The benefits of transporting SR spring/summer Chinook salmon varies depending on the time of the season they are transported, in-river conditions (such as temperature), river flow, and ocean conditions. For example, in-river survival of juvenile SR spring/summer Chinook salmon in 2015 (a year that had extremely low flows and high temperatures in the mainstem Snake and Columbia rivers) was relatively low (45.7 percent), and the transport:benefit (T:B) ratio was relatively high for hatchery spring/summer Chinook salmon (T:B ratio of 3.7:1) and wild spring/summer Chinook salmon (T:B of 29.7:1) (NMFS 2019).

In the event an emergency operation to collect and transport adult Snake River sockeye salmon is implemented due to high water temperatures at the Snake River projects, it is possible that juvenile Snake River spring/summer Chinook salmon may be harmed, injured, or even killed during the process of collecting and sorting adult sockeye salmon. However, it is very unlikely to this would occur, with the number of individuals injured or killed expected to be very low. During a Snake River sockeye salmon passage emergency, impacts are likely similar to those estimated in 2015, with less than 15 sub-yearling Chinook and less than 50 yearling Chinook exposed to possible injury per day from mid-July to early August (NMFS 2016c).

Mainstem CR Fish Travel Time

Under the flex spill plan, spring operations at the eight mainstem CRS dams will include spilling to state water quality limits (anticipate 125 percent starting in 2020) for 16 hours per day and to performance spill operations for 8 hours per day. Patterns and amounts for the performance spill operation were developed using a combination of prescribed spill and performance standard testing guidelines from the 2008 FCRPS BiOp and gas cap spill that uses spill up to state water quality standards, with some restrictions for erosion concerns and powerhouse minimums. The main effects of increased spill discharge will be a decrease in forebay delay and an increase in spill passage efficiency, with a reduction in hypothesized latent/delayed mortality (NMFS 2019).

Modeling estimates for SR spring/summer Chinook salmon indicate fish travel time from McNary Dam to Bonneville Dam will be slightly reduced. Additional flow through the spill bays will likely draw a greater proportion of juvenile spring/summer Chinook salmon migrants from the powerhouse routes (turbine and bypass) and surface passage routes (surface weir and sluiceway). Model estimates suggest that implementation of the Proposed Action could decrease juvenile travel time by approximately 8–14 percent. Decreasing smolt travel time with higher levels of spill through the CRS can provide a survival advantage due to reducing exposure time to predators and fostering a more normative synchrony between the physiological process of smolt transformation and the timing of seawater entry.

Under the Proposed Action, juvenile fish transportation would be suspended on June 14 through August 15, then reinitiated and continued through November 15. Stopping transport in mid-June may affect the end of the SR spring/summer Chinook outmigration. Although there may be few fish still migrating downstream, they are the ones that benefit most from transportation, so this could lower juvenile migration success. The reinitiating of juvenile fish transportation after mid-August would be after the SR spring/summer outmigration and is not anticipated to affect this ESU. Second, the higher spill under MO4 would substantially decrease the proportion of smolts transported during the spring spill season, because fewer fish would be passing through the juvenile fish bypasses (a higher proportion would pass via spillways) and, thus, not available for transport. The life cycle implications of these juvenile experiences are discussed further in adult survival.

Powerhouse Passage Proportion

In addition to increasing spill in the spring, the Action Agencies propose to modify spillway weirs and turbines at Ice Harbor, McNary, and John Day dams. These actions to improve baseline structural conditions are anticipated to increase survival of juvenile fish that pass through those routes. In addition, increasing the proportion of water discharged as spill directs a higher fraction of migrants away from powerhouses and toward spillways. This will reduce smolt encounters with turbines and intake screen bypass systems, both of which have been hypothesized to contribute to latent/delayed mortality. The models predict a potential decrease in powerhouse encounters (COMPASS 78 percent; CSS 84 percent), which could benefit SR spring/summer Chinook salmon.

Total Dissolved Gas

Spill at CRS dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. This may occur during periods of high flows, when involuntary spill is necessary, or during set

periods of time when water is spilled purposefully to implement the Proposed Action. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, which can result in injury or death. Survival of juvenile salmonids can decrease when TDG levels exceed lethal limits and fish are not able to compensate by swimming into deeper water (Beeman and Maule 2006).

Biological monitoring within the CRS shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 125 percent of saturation (Antcliffe et al. 2002; Backman et al. 2002; NMFS 2019). When those levels are exceeded, however, there is a corresponding increase in the incidence of signs of GBT symptoms. McGrath et al. (2006) determined that new research supports previous research indicating that short-term exposure to up to 120 percent TDG does not produce significant effects on juvenile (or adult) salmonids when compensating water depths are available (Beeman and Maule 2006; NMFS 2019). Therefore, it is anticipated that any increase in TDG as a result of implementing the flex spill operation will result in negligible increases in GBT to outmigrating juvenile SR spring/summer Chinook through the CRS, because the Proposed Action is not intended to exceed the 125 percent “gas cap” during periods of voluntary spill.

Temperature

Temperature influences growth and feeding rates, metabolism, development, migration timing, and the availability of food. In addition, temperature plays a role in predator fish behavior, which also affects juvenile salmonid survival. Adverse (high) water temperatures, however, can cause stress and mortality to SR spring/summer Chinook.

Current temperature conditions are different from historical, as a result of a suite of anthropogenic activities described in the status of the species section, but are generally not elevated sufficiently to be detrimental to SR spring/summer Chinook salmon during the time juveniles are actively migrating downstream. The Proposed Action is not anticipated to change the current temperature regime in the river during the time that SR spring/summer Chinook salmon juveniles are migrating downstream through the CRS. Therefore, it is anticipated that temperature changes attributable to the Proposed Action are likely indistinguishable from current conditions and will result in negligible effect to outmigrating juvenile SR spring/summer Chinook salmon.

Turbidity

The existence of the CRS (and non-federal dams) has decreased sediment transport downstream in the Columbia River Basin, as suspended particles tend to settle out when sediment-laden water enters a reservoir, thereby reducing turbidity. These conditions are part of the environmental baseline. Lowered turbidity levels may increase the susceptibility of SR spring/summer Chinook to avian and piscivorous predators because of increased visibility in the water column.

Implementing the Proposed Action is unlikely to result in changes in the amount of suspended sediment (and resulting turbidity) in the water column through the CRS. However, while outmigrating juvenile SR spring/summer Chinook will continue to experience a less turbid system as a result of past actions, the Proposed Action does include measures to address predation impacts in the vicinity of the dams and in the estuary, as described next.

Predation

A variety of bird and fish predators consume juvenile SR spring/summer Chinook on their migration from tributary rearing areas to the ocean (see Section 3.2.1.4). Existing conditions create habitat that is more ideal for both native and non-native predatory fish than pre-CRS conditions. Outmigrating juvenile SR spring/summer Chinook encounter predatory fish during passage through reservoirs, dam forebays, and dam tailraces of the CRS.

Implementing operations of the Proposed Action will not substantially change environmental baseline conditions for the distribution and abundance of piscivorous fish in the CRS. Thus, while outmigrating SR spring/summer Chinook are anticipated to continue to be exposed to predation in the CRS, conditions under the Proposed Action are not anticipated to worsen. On one hand, fish in the dam tailraces that may be particularly susceptible to predation could benefit from the flex spill program through increased spill discharge increasing turbulence immediately downstream of the dams, making it more difficult for predators to locate and prey upon juvenile salmonids in these areas. On the other hand, increased spill discharge may increase disorientation of outmigrants in spillway tailwaters, leading to increased vulnerability to avian predation.

Juvenile Chinook salmon survival is expected to increase by up to 1% through the John Day Reservoir during the spring migration period as a result of deterring Caspian tern nesting at Blalock Island Complex with increased reservoir elevations as defined by the proposed action (see Chapter 2) (Evans et al. 2019). Increased reservoir elevations are expected to decrease travel rates through the John Day reservoir. Decreased travel rates may increase vulnerability to predation by piscivorous fish.

Non-Operational

Predation Management

Management efforts to reduce predation by birds and northern pikeminnow will continue with the Proposed Action. Collectively, these efforts are intended to continue to minimize predation rates on outmigrating juvenile SR spring/summer Chinook passing through the CRS.

The Action Agencies have developed various plans to help minimize predation by birds. In 2005, the Caspian Tern Management Plan was approved (USFWS 2005), and in 2014, the Inland Avian Predation Management Plan (IAPMP) began (Corps 2014a). These plans manage avian predation on juvenile salmonids as they migrate to the ocean by redistributing bird nesting colonies in the estuary (USFWS 2005) or inland (Corps 2014a) to other nesting sites in the western United States. Continued implementation of these plans in the Proposed Action will continue to minimize predation from birds on juvenile salmonids, including SR spring/summer Chinook salmon.

Based on PIT-tag recoveries at East Sand Island (near the mouth of the Columbia River), average annual tern and cormorant predation rates for SR spring/summer Chinook salmon were about 4.8 and 5.2 percent, respectively, before efforts to manage the size and nesting location of these colonies (Evans et al. 2018). Previous management actions implemented by the Action Agencies to relocate various tern colonies has had some positive effect by reducing the predation rate on SR spring/summer Chinook salmon to 1.5 percent (Evans et al. 2018). Efforts to minimize predation by birds will continue with the

Proposed Action. The flex spill program may also decrease predation in CRS dam tailraces by increasing the turbulence downstream of the dams, making it more difficult for birds to locate and prey upon juvenile salmonids.

The northern pikeminnow, a native fish, is a significant predator of juvenile salmonids in the Columbia River. In 1990, the Action Agencies began the Northern Pikeminnow Management Program (NPMP) to reduce predation on juvenile salmonids by northern pikeminnow through targeted removal of northern pikeminnow at mainstem CRS dams. In addition, a Pikeminnow Sport Reward Fishery program has been instituted that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake Rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. Incidental catch of ESA-listed salmon and steelhead as a result of implementing pikeminnow management programs has occurred in the past and is likely to continue at a similar rate in the future. While the numbers are low, some individuals are likely part of the SR spring/summer Chinook ESU.

Predator management programs will continue under the Proposed Action. They are anticipated continue to maintain benefits achieved to date for reducing consumption of juvenile salmon and steelhead by avian and fish predators. The proposed measure at John Day to inundate the Blalock islands during and to dissuade tern nesting would benefit spring migrating salmon and especially steelhead. Further, continuing to implement the Caspian tern and cormorant management plans and the NPMP will result in negligible changes in predation, but will prevent the impacts from “backsliding” to levels that were occurring prior to the Action Agencies implementation of these plans.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on SR spring/summer Chinook associated with the capturing and handling of fish. RM&E activities occur throughout the Columbia River Basin as part of managing the CRS. In general, the RM&E program is a collaborative, regionally coordinated effort for status and trend monitoring for habitat and fish, action effectiveness monitoring and research, critical uncertainty research, synthesis and evaluation, and data management. Capturing, handling, marking, tagging, and releasing fish is generally stressful and can have sublethal and sometimes lethal effects. Furthermore, some RM&E actions also involve euthanizing fish for research purposes. NOAA Fisheries (2019) estimated the number of juvenile SR spring/summer Chinook that have been handled each year during the implementation of RM&E under the 2008 BiOp and determined that the average handling and mortality were not substantial. They concluded,

... slightly more than 1 percent of the wild juvenile production was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to 1 percent of these juveniles (in this case, < 0.02 percent of the wild production) died after they were released due to effects of handling. This relatively small effect is deemed worthwhile, because it allows the Action Agencies and NMFS to evaluate the effects of FCRPS operations, including modifications to facilities, operations, and mitigation actions.

It is reasonable to assume that implementing the Proposed Action will result in the number of individual SR spring/summer Chinook handled, injured, and/or killed from RM&E activities at CRS dams will continue at approximately the same level in the future.

Juvenile SR Spring/Summer Chinook Estuary Migration and Rearing, Including the Plume

Ecosystems in the estuary (defined as Bonneville Dam to the ocean) and Columbia River plume provide habitat for juvenile SR spring/summer Chinook to migrate in, forage, adapt physiologically, and, in some cases, avoid predators. Most yearling spring/summer Chinook salmon move through the estuary in 1 or 2 days, and survival in this reach appears to be high (Daly et al. 2014). The existence and operations of the CRS has led to long-standing changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, any direct impacts on these parameters due to the Proposed Action of continuing CRS management are expected to be minor.

In addition, there is an apparent relationship between plume characteristics at time of ocean entry and SARs for Chinook salmon. Jacobson et al. (2012) found that Chinook salmon SARs increased with the size and offshore distance of the plume under favorable large-scale ocean conditions, but did not change when ocean conditions were poor (Jacobson et al. 2012).

Avian predation continues to be a serious issue in the estuary (see Section 3.2.1.4). Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary will benefit this ESU by reducing the number of individuals of this ESU eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1].

The indicators used below to assess the effects of the Proposed Action on juvenile SR spring/summer Chinook migration through the estuary and plume are categorized as operational (survival, fish travel time, TDG, temperature, turbidity, and predation) and non-operational (predation management and fish status and trend monitoring). Using these indicators, analyses of effects to SR spring/summer Chinook during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Survival

Foraging and growth in the estuary improves fish condition and likely increases subsequent survival during early ocean residence. Monitoring and research data suggest that fish size and time of ocean entry, which are in part due to conditions in the estuary, can affect salmonid growth and survival in the ocean (Chittaro et al. 2018; Johnson et al. 2018). Habitat enhancements that increase access to rearing areas, improve habitat capacity (e.g., prey productivity), and increase prey export to the mainstem estuary likely lead to increased growth and improved condition of migrating juvenile SR spring/summer Chinook in the estuary.

Fish Travel Time

Changes in CRS water management in the Proposed Action are not expected to alter fish travel time through the estuary. Therefore, under the Proposed Action, travel time in the estuary of juvenile SR spring/summer Chinook is not likely to change from the baseline condition.

Total Dissolved Gas

As mentioned previously, GBT was historically a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that water did not plunge to depth and force gas into saturation (NMFS 2019). Elevated TDG levels are expected during periods of increased spill downstream until attenuated at approximately RM 110 (NMFS 2019). Juvenile SR spring/summer Chinook exposed to increased TDG levels (120 percent to 125 percent) are likely to experience slight increases of GBT compared to baseline conditions.

Temperature

As mentioned above, during the time when juvenile SR spring/summer Chinook are outmigrating, the proposed operation of the CRS has limited capabilities to modify water temperatures in the mainstem Snake and Columbia Rivers. Therefore, water temperature changes are not expected under the Proposed Action upstream of Bonneville Dam, nor are they anticipated for the estuary reach downstream from Bonneville Dam.

Turbidity

As mentioned previously, baseline turbidity is modified from historical conditions, and it is not anticipated that implementing the Proposed Action will effect turbidity conditions in the CRS, including the section downstream from Bonneville Dam.

Predation Rates

The Proposed Action is not anticipated to have any effect on the rate of predation of juvenile salmonids in the Columbia River estuary and plume.

Non-Operational

Predation Management

The Proposed Action will continue to implement the various predator management programs that are currently being implemented in the estuary and mainstem Columbia River. Some ESA-listed fish are captured as part of implementing the Pikeminnow Sport Reward Fishery and dam angling program. The number of individual fish impacted is likely to continue at a similar rate in the future. While the numbers are low across the entire program, some individuals below Bonneville Dam and in the estuary may be captured, injured, or killed.

Estuary Habitat Actions

As part of the Proposed Action, the Action Agencies will continue implementing the CEERP to improve estuary floodplain habitats, including tidally influenced portions of tributaries, used by outmigrating salmon and steelhead. The planned improvements in habitat functions are expected to provide long-term benefits to native species that use these habitats through improved ecological functions and processes. Appropriate ESA consultation is typically undertaken prior to implementation of these projects at site-specific scale. These ESA consultations are complete with implementing Terms and Conditions that the Action Agencies comply with. Project effectiveness is expected to increase over time as the restoring habitats mature and new, more effective restoration projects are implemented, because program sponsors will be taking into account lessons learned from previous projects within CEERP's adaptive management framework (Diefenderfer et al. 2016).

Fish Status and Trend Monitoring

The RM&E component of CEERP includes actions to monitor status and trends of habitat and fish, perform action effectiveness monitoring and research, and conduct critical uncertainties research. CEERP is implemented using an adaptive management process to capture learning from RM&E and adjust accordingly program strategies and actions (Johnson et al. 2018). RM&E will continue under the Proposed Action. Capturing and handling of juvenile salmon and steelhead may result in stress, injury, or mortality as part of RM&E in the estuary and plume.

Ocean Rearing

CRS management has no direct influence on survival of SR spring/summer Chinook in the Pacific Ocean. There are, however, a small number of individual salmon and steelhead that could experience deleterious direct effects from capture and handling from a Bonneville-funded study of juvenile salmonid ecology in the plume and nearshore ocean. Indirect effects on survival of SR spring/summer Chinook from CRS management include any latent/delayed mortality manifested in the ocean and the positive influence CRS management can have on juvenile migration and growth in the estuary, which is related to improved survival during early ocean entry.

The Proposed Action will have no effect on the ocean habitats used by SR spring/summer Chinook for growth and maturing, because there are no CRS operations that affect this area (the Columbia River plume was addressed above).

Adult SR Spring/Summer Chinook Migration to Bonneville Dam

Adult SR spring/summer Chinook tagged in the estuary took from 7 to 57 days (usually 15 to 18 days) to reach Bonneville Dam (Wargo Rub et al. 2012a, b). From 2010 to 2016, on average, 77 percent of the tagged fish reached Bonneville Dam (NMFS 2017e). It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the estuary past Bonneville Dam by the distance from the facilities and the estuary tributary flows. The Proposed Action is unlikely to cause adult migration barriers for SR spring/summer Chinook downstream of Bonneville Dam, and streamflow is sufficient for

adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. Pinniped management actions at Bonneville Dam are expected to reduce this impact to some degree. Thus, overall, the Proposed Action is likely to have negligible effects on SR spring/summer Chinook adult migrations from the ocean to the CRS.

Further analysis of effects to adult SR spring/summer Chinook returning to the Columbia River and migrating up to Bonneville Dam as a result of implementing the Proposed Action is described next. The analysis is organized by operational and non-operational components.

Operational

Travel Time

The Proposed Action is not expected to negatively affect the migration rate of adult SR spring/summer Chinook in the estuary. The Proposed Action will result in negligible flow reductions and, thus, a minor reduction in water particle velocity at the time adult spring/summer Chinook will be entering and migrating through the estuary. Therefore, the Proposed Action is not expected to result in a measurable increase or decrease in migration rate.

Total Dissolved Gas

The Proposed Action includes a flex spill component, which during spring spill operations will result in spill at CRS projects to a level where the state water quality limit (125 percent) for TDG is met 16 hours per day, with a performance standard spill (120 percent) component totaling 8 hours per day. As such, TDG levels will reach 120 percent of saturation during the 16-hour block and a lesser amount during the performance spill component.

Populations of SR spring/summer Chinook enter the Columbia River estuary and pass over Bonneville Dam from April through June, with peak migration in mid-May (NMFS 2019; Wargo Rub et al. 2019). Since the flex spill program will occur April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects, most adult SR spring/summer Chinook will be exposed to slightly elevated levels of TDG. However, based on the attenuating effect of the distance downstream of the system, and the influence of tributary streamflow, effects of the Proposed Action are anticipated to have negligible effects on SR spring/summer Chinook adults migrating up the estuary to Bonneville Dam.

Temperature

Poor water quality, which includes increased water temperature, can lead to stress in adult SR spring/summer Chinook, which in turn, can lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth and osmoregulation). Furthermore, elevated water temperatures can affect salmonid distribution, behavior,

migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult SR spring/summer Chinook (NMFS 2019).

Because actions associated with the Proposed Action will not result in elevated water temperatures downstream from Bonneville Dam, effects of the Proposed Action are not expected to negatively impact adult SR spring/summer Chinook within this reach.

Turbidity

Existence of the CRS has decreased sediment loads transported downstream by the Columbia River. In fact, it is estimated that the total sediment discharge into the estuary and the Columbia River plume is approximately one-third of pre-hydrosystem levels (NMFS 2019).

Because actions associated with the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam, the Proposed Action is not expected to negatively impact adult SR spring/summer Chinook within this reach.

Non-Operational

Predation Management

For upstream migrating adult SR spring/summer Chinook, the primary factor affecting survival to Bonneville Dam is pinniped predation. The existence of Bonneville Dam, which is part of the environmental baseline, likely causes pinnipeds to congregate downstream from that project. However, if Bonneville Dam were not present, the pinnipeds would likely congregate at Cascade Falls or other upstream falls, much like they do at Willamette Falls.

Estimates of pinniped predation downstream of the Bonneville Dam are not available specifically for adult SR spring/summer Chinook. However, salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). Wargo Rub et al. (2019), as cited in NMFS (2019), estimated that up to 50 percent of the mortality from pinnipeds of adult spring-run Chinook salmon destined for tributaries above Bonneville Dam occurred within the 10-mile reach just below the dam. Tidwell et al. (2018), as cited in NMFS (2019), reports that an estimated 4,951 adult spring Chinook salmon (all ESUs) were consumed by both pinniped species in 2017, which equates to 4.5 percent of the adult spring Chinook salmon that passed. Consumption rates of spring Chinook salmon in the last 3 years (2015–2017) have ranged from 4.3 to 5.9 percent and are the highest consumption rates since monitoring begun in 2002.

To reduce the baseline condition of pinniped predation on adult salmonids, management measures such as hazing, removal, and structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates) will continue under the Proposed Action. No components of the Proposed Action are expected to change from current conditions associated with pinniped predation and, therefore, will not affect adult SR spring/summer Chinook.

Adult SR Spring/Summer Chinook Migration Through CRS Dams

Most SR spring/summer Chinook populations will migrate upstream through all eight Lower Columbia and Snake River CRS projects on their way to spawn. The one exception is the Tucannon River population, which will migrate through the Lower Columbia projects plus Ice Harbor and Lower Monumental Dams.

Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life stages, such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

As reported earlier, after accounting for reported harvest rates and expected stray rates, adult SR spring/summer Chinook have relatively high survival rates passing the Lower Columbia and Snake River CRS dams (six CRS projects for the Tucannon population; (NMFS 2019). Based on conversion rates of PIT-tagged SR spring/summer Chinook detected at Bonneville Dam for the years of 2008 to 2017, the estimate of minimum survival for the Bonneville to McNary reach averaged 88.7 percent over the 10-year period (range of 82.8 to 100.0 percent). This estimate of minimum survival includes all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 96.1 percent per project (NMFS 2019). Based on the same dataset, the minimum survival estimate for the Bonneville to Lower Granite Dam reach has been estimated to be 84.3 percent (range of 77.2 to 93.5 percent). Based on this estimate of reach survival, per project survival averages 97.6 percent (NMFS 2019).

An analysis of effects to adult SR spring/summer Chinook migrating upstream through the CRS as a result of implementing the Proposed Action is described next, organized by Operational and Non-operational actions.

Operational

As discussed previously, the Proposed Action includes a flex spill program for spill at CRS projects to a level where the state water quality limit for TDG is met 16 hours per day, and a performance spill component is implemented 8 hours per day. The flex spill program will occur April 3 through June 20 at the lower Snake River projects and April 10 through June 15 at the lower Columbia River projects.

The Proposed Action also includes modifying the Bonneville ladder serpentine weir to reduce delay within the fishway (this structural change is included under operational effects for convenience) and providing flexibility to decrease pool elevation in John Day Reservoir by 0.5 feet to increase water particle velocity and reduce fish travel time. Collectively, these measures, along with the flex spill program, have the potential to affect SR spring/summer Chinook, as described next.

Modeling Results

Because of differing assumptions and drivers in the models, and possibly also because of the different populations modeled, the life cycle models used produced widely differing results for adult SR spring/summer Chinook salmon SARS and abundance. The NWFSC LCM, comparing MO4 to the NAA 2016 operations, indicated a 12 percent decrease in SARS and an average 32 percent decrease in abundance of adult returns to spawning grounds. CSS, on the other hand, predicts MO4 would increase

SARS by 75 percent and nearly double the abundance of adult returns. These metrics are displayed in Table 3-25.

It is important to remember that the juvenile survival indicated in the COMPASS metrics in the juvenile survival table applies to in-river migrating smolts only. Transported smolts are designated a survival rate of 98 percent from Lower Granite Dam to Bonneville Dam, compared to around 50 percent for in-river smolts. In MO4, the lower proportion of transported fish results in more smolts experiencing the lower survival rate of the in-river travel. Supporting this explanation, CSS indicates an advantage to in-river fish in this alternative. One of the drivers of the ocean survival module is the arrival timing of smolts to the ocean; because fewer smolts would be transported, a higher proportion of smolts would travel in-river. In-river migrants have much lower survival rates and much later arrival timing than in-river fish; the result would be fewer juveniles make it to the ocean, and they would have lower survival to adulthood, as indicated by a decrease in SARS. Timing is also important; generally-speaking, fish transported later in the season experience better SARS than in-river fish, but earlier in the season there is more benefit to in-river travel. This makes sense, as the later it gets in the season, challenges to in-river survival, such as predation and thermal stress, tend to increase. MO4 would cease transport in mid-June, when the survival benefit of being transported would be greatest. It is important to note, however, that the lower rate of transported smolts would result in fewer adults straying to different populations than their origin.

Table 3-25. Model metrics for adult SR spring/summer Chinook salmon

Metric (Model)	NAA	MO1	MO4	Change from NAA	% Change
LGR-BON SARS (NWFSC LCM) ^a	0.88%	0.88% (0%) 0.93% (10%) 1.00% (25%) 1.12% (50%)	0.77% (0%) 0.84% (10%) 0.94% (25%) 1.12% (50%)	-0.11% (0%) -0.04% (10%) +0.06% (25%) +2.4% (50%)	-12% (0%) -4% (10%) +8% (25%) +27% (50%)
LGR-BON SARS (CSS)	2.0%	2.2%	3.5%	+1.5%	+75%
Abundance of South Fork Salmon and Middle Fork Salmon River representative populations (NWFSC LCM)	2,351	2,411(0%) 2,563(10%) 2,826(25%) 3,290(50%)	1,590 (0%) 1,944 (10%) 2,489 (25%) 3,586 (50%)	-761 (0%) -407 (10%) +138 (25%) +1,235 (50%)	-32% (0%) -17% (10%) +6% (25%) +53% (50%)
Abundance (CSS) ^b	6,114	6,428	12,159	+6,045	+99%

BON = Bonneville Dam; CSS = Comparative Survival Study; LCM = Life Cycle Model; LGR = Lower Granite Dam; NWFSC = Northwest Fisheries Science Center; SAR = smolt-to-adult ratio;

^a NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARS or abundance output. For discussion purposes, potential increases in ocean survival of 10%, 25%, and 50% are shown. The value for 0% is the actual model output, the 10%, 25%, and 50% values represent scenarios of what SARS or abundance hypothetically could be under the increased ocean survival if changes in the alternative were to decrease latent mortality by that much.

^b CSS provided results for six populations in the Grande Ronde/Imnaha major population group. The absolute values represent those populations only; the percent change is considered indicative of the Snake River ESU of UCR spring Chinook salmon for the purpose of comparing between alternatives.

One major difference between the models is in the ocean survival module. CSS incorporates data related to increased or decreased latent mortality, depending on the hydrosystem experience of each smolt. For

MO4, ocean survival was predicted to increase from 3.6 percent under the NAA to 5.7 percent in MO2 (a 60 percent increase in ocean survival). Factors such as fewer powerhouse encounters and decreased travel time are assumed to increase survival in the ocean due to decreased latent mortality from a smolt's experience through the CRS operations projects, which would, in turn, increase the abundance of returning adults to the Columbia River.

If a similar factor of change in ocean survival is applied to the NWFSC LCM results, the model predicts an abundance increase under MO4. Hypothetically, the model run with increased ocean survival indicates an increase of 53 percent more adults than the NAA if ocean survival were to increase by 50 percent

Fallback

Adult SR spring/summer Chinook can fallback at dams while migrating upstream to their natal streams. Typical fallback occurs after an individual ascends a fishway and then passes back downstream from the project in a relatively short period of time. This activity is often associated with higher spill levels at the project. Results from radio telemetry research for the years of 1995 to 2003 show that (1) after fallback, re-ascension rates are highest at downstream dams; (2) that 19 percent of spring/summer Chinook fall back at least once; (3) fallback rates are correlated to flow at most Columbia and Snake River dams; and (4) fish that fallback are significantly less likely to reach spawning grounds relative to fish that never fell back [Keefer et al. (2005) as cited in NMFS (2019)]. PIT-tag detections at Bonneville Dam for the period of 2006 to 2011 show that 9.6 percent of spring/summer Chinook that fall back at that project subsequently re-ascend that project's fishways [DART (as cited in NMFS (2019))].

The Proposed Action, specifically the flex spill component, will have the potential to increase the rate of fallback at the four lower Columbia River dams. With increased spill, it is likely more of the fish that fall back at a given project will do so through the spillway, or some surface-oriented passage route. However, spill at lower Columbia River dams will terminate on June 15. For fish that do fall back during the flex spill program, and specifically through the spillway or a surface structure, survival of that fallback event is relatively high. At Bonneville Dam, direct survival tests using rainbow trout as a surrogate revealed that for fish passing downstream of the dam via the Ice/Trash sluiceway and the corner collector, survival was greater than 98 percent (after 48 hours). At McNary Dam, direct survival was estimated to be approximately 98 percent through the TSW. Conversely, direct survival through the McNary turbines was estimated to be approximately 91 percent (Keefer et al. 2016). For later migrating fish (i.e., those that ascend the CRS after termination of the flex spill program), rate of fallback is not expected to change.

Total Dissolved Gas

Populations of SR spring/summer Chinook enter the Columbia River estuary and pass over Bonneville Dam typically during the April to June period, with peak migration in mid-May (NMFS 2019; Wargo Rub et al. 2019). Since the flex spill program will occur April 3 through June 20 at the lower Snake River projects and April 10 through June 15 at the lower Columbia River projects, most adult SR spring/summer Chinook will be exposed to elevated levels of TDG.

As described in the previous section, GBT is not typically observed when TDG levels do not exceed 120 percent and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Elevated TDG levels are only expected to be encountered below McNary

Reservoir and will be reduced as adults continue upstream past the confluence with the Snake River. Therefore, based on the limited observations of GBT at expected TDG levels associated with the Proposed Action and given the timing of adult SR spring/summer Chinook salmon within the CRS, the Proposed Action is not expected to result in an elevated risk of GBT to SR spring/summer Chinook.

Temperature

As described previously, poor water quality, including increased water temperature, can have adverse effects on adult SR spring/summer Chinook salmon. However, because actions associated with the Proposed Action are not anticipated to elevate water temperatures within the CRS, effects of the Proposed Action are not expected to affect adult SR spring/summer Chinook within this reach.

Turbidity

Hydropower development in the Pacific Northwest has altered the extent of sediment transport downstream through the Columbia River, including within the CRS. While other anthropogenic activities, such as agriculture, irrigation, mining, logging, road building, etc., have increased sediment delivery to the mainstem Columbia River, both federal and non-federal projects act as sediment traps, decreasing sediment loads discharging downstream. These activities and baseline conditions are expected to continue at current rates.

Because actions associated with the Proposed Action are not expected to result in changes in baseline sediment load, the Proposed Action is not expected to affect adult SR spring/summer Chinook within this reach.

Non-Operational

Predation Management

Predation on adult SR spring/summer Chinook within the CRS is rare. Pinnipeds are the primary predator of adult salmon and steelhead, and while pinniped predation commonly occurs in the Bonneville Dam tailrace and in the estuary downstream to the Pacific Ocean, pinniped observations upstream from Bonneville Dam are not common; no pinnipeds have been observed above The Dalles Dam. The Proposed Action is not expected to change pinniped predation on adult UCR steelhead in the CRS.

Measures intended to reduce predation on adult salmonids, such as hazing, removal, and use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates), will continue. Furthermore, if pinnipeds are observed in the tailrace of The Dalles Dam, hazing efforts may be implemented at that project's ladder entrances.

In addition, predator fish management programs, like the NPMP, could potentially effect SR spring/summer Chinook by the accidental hooking of adults at the dams and during fishing for northern pikeminnow elsewhere in the CRS. There is also potential for by-catch while the number of pikeminnow are being indexed through electroshocking. However, the incidental catch of adult SR spring/summer Chinook during these activities has remained below take limits for the NPMP (Williams et al. 2019).

Adult SR Spring/Summer Chinook Migration Upstream of the CRS to the Spawning Areas

After migrating upstream through the CRS, adult SR spring/summer Chinook begin to migrate to their natal streams. For the most part, exposures to the majority of CRS-related water quality and quantity aspects of the Proposed Action are reduced dramatically after passing the Snake River confluence, though some influence from upper mainstem dams and other upriver CRS projects is still occurring. Once they enter their natal tributaries, they are no longer exposed to the operation and related effects of the CRS. Within the Snake River tributaries that support the spawning and rearing of SR spring/summer Chinook populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, forestry practices, and human development. Impacts associated with those activities include impaired tributary fish passage and degraded freshwater habitat, including reduced floodplain connectivity and function, degraded channel structure and complexity, reduced riparian areas and large woody debris recruitment, reduced streamflow, and reduced water quality (NMFS 2019).

Within SR spring/summer Chinook tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this ESU. The following provides a more detailed description of the effects of those actions.

Hatchery Programs

There are a total of 10 artificial propagation programs included in the SR spring/summer Chinook ESU and 8 other spring/summer Chinook artificial propagation programs within the ESU's geographical range that are not included in the ESU (NMFS 2019).

None of the hatchery programs described above are included within this Biological Assessment, because they have been or are in the process of separate ESA consultations. Also, none of the measures within the Proposed Action will alter current hatchery practices within this ESU's range and, therefore, no affect to SR spring/summer Chinook is anticipated.

Tributary Habitat Actions

For SR spring/summer Chinook, habitat degradation is the result of past and present anthropogenic activities. Tributary habitat for SR spring/summer Chinook varies significantly throughout the Snake River. In some areas, habitat is minimally degraded; in other areas, it is highly degraded; and in still other areas, spawning and rearing habitat is in near-pristine condition.

As described previously, many factors limit the viability of this ESU. In response, many habitat measures have been implemented specifically to benefit SR spring/summer Chinook by federal, state, local, and private entities, including the Action Agencies.

Based on the best available science, NMFS has concluded that these actions have improved, and will continue to improve, habitat for SR spring/summer Chinook as these projects mature. Furthermore, they concluded that fish population abundance, productivity, spatial structure, and diversity should respond positively (NMFS 2019).

Passage Emergency Operation

If a SR sockeye salmon passage emergency operation is declared due to high water temperatures at the Snake River projects, some juvenile Chinook may be collected and incur mortality incidental to the process of collecting and sorting adult sockeye. Injury is expected to be low. If an SR sockeye salmon passage emergency operation is declared, impacts may be similar to those estimated in 2015; approximately 15 subyearling chinook and less than 50 yearling Chinook may be injured per day from mid-July to early August (NMFS 2015).

Fish Status and Trend Monitoring

It is anticipated that the Action Agencies' RM&E program will continue at current levels of effort or, perhaps, at somewhat reduced levels. As such, the level of injury and mortality associated primarily with the capture, handling, and marking/tagging of SR spring/summer Chinook is expected to be maintained at current or slightly decreased levels.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Effects of the Proposed Action on critical habitat for SR spring/summer Chinook were assessed based on the action's elements likely to affect PBFs essential for the conservation of the DPS. Effects cover critical habitat for tributary spawning and rearing, the freshwater migration corridor through the mainstem CRS dams, and the estuary and nearshore ocean.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of SR spring/summer Chinook salmon. Freshwater spawning and rearing areas occur upstream of the CRS, so the effects of the Proposed Action are limited to tributary habitat mitigation actions, which are intended to improve habitat function for SR spring/summer Chinook salmon. For the Tributary Habitat Improvement Program, there will be some uncertainty about the actual locations, extent, and types of tributary habitat actions that will be implemented as part of the Proposed Action. However, anticipated effects of the program are expected to be short-term and will be mitigated through compliance with the BiOp on Columbia River habitat improvements (NMFS 2013). The operation and maintenance of these programs have undergone separate, program-specific ESA consultation with (NMFS 2019) and are part of the existing baseline conditions.

Freshwater Migration Corridors

Freshwater migration corridors are used by returning adult Chinook salmon migrating upstream through the CRS and by juvenile Chinook salmon migrating downstream. The CRS dams and reservoirs have affected, and will continue to affect, the function of critical habitat within the mainstem Columbia and Snake Rivers, which continues to influence passage and survival of juvenile and adult migrants and is part of the environmental baseline. The Proposed Action includes ongoing actions to maintain or improve the freshwater migratory PBFs through operation and maintenance of passage improvements through the system and implementation of the predator management programs, which is intended to

reduce the consumption of juvenile and adult salmon within the CRS. These programs are intended to improve downstream survival and will continue to reduce the risk of predation on SR spring/summer Chinook salmon.

The Proposed Action also includes both structural and operational modifications to the CRS that may affect water quality and passage PBFs that SR spring/summer Chinook salmon must migrate through to complete their life cycle. However, the overall effect to these PBFs from implementing the Proposed Action are slightly positive, with respect to passage conditions and risk of predation, and slightly negative relative to elevated exposure to TDG. Continued effects to stream temperature, sediment, and turbidity are anticipated with CRS management, but effects to these water quality PBF indicators are likely to remain unchanged as a result of the Proposed Action. Passage conditions at each of the projects are anticipated to improve for juvenile Chinook salmon, as the flex spill program will provide more advantageous passage routes through spill bays at each of the projects. Increasing the proportion of water discharged through the spill bay surface weirs at each of the dams will reduce forebay residence time by providing a more pronounced, surface-oriented flow path for juvenile Chinook salmon, which decreases forebay residence time, improves dam passage survival, and is hypothesized to reduce latent/delayed mortality.

Estuarine and Nearshore Marine Areas

Estuarine and nearshore marine areas have been designated as essential for the conservation of SR spring/summer Chinook salmon. Ongoing implementation of the Columbia Estuary Ecosystem Restoration Program and predator removal and harassment programs is anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of the CEERP is likely to increase the capacity and quality of habitat in the estuary while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal and harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to improve the safe passage feature of critical habitat.

The Proposed Action includes operational modifications to the CRS that may affect water quality habitat features downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions, with a slight but potential increase in TDG associated with the flex spill program. The highest TDG levels (125 percent) are expected in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). Continued effects to the PBFs associated with stream temperature, sediment, and turbidity are anticipated downstream from the CRS but are likely to remain unchanged as a result of the Proposed Action. Current passage habitat features will be unaffected for juvenile and adult SR spring/summer Chinook as they migrate through the Columbia River estuary and into nearshore ocean.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on SR spring/summer Chinook salmon in the context of environmental baseline and cumulative effects. Cumulative effects are effects of future state

or private activities that are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline condition (whether they are federal, state, or private). To the extent those same activities are reasonably certain to occur in the future (and are state or private), their future effects are included in the cumulative effects analysis.

Most of the effects identified in the analysis above are consistent with effects previously described for management of the CRS in past consultations; thus, they are part of the existing baseline conditions. In general, the Proposed Action does not result in substantial changes in these conditions, though there may be some modest, site-specific effects. Of particular interest is whether the increased pill levels and associated adverse effects are offset by an increase in adult salmon and steelhead returns due to less powerhouse encounters, as hypothesized by the CSS.

The summary below follows the general structure of the effects analysis above, having operational and non-operational components.

Operational

Survival

Baseline survival of juvenile SR spring/summer Chinook salmon through the CRS is affected by the number of hydroelectric projects they pass, predators, travel time, and water quality. These factors are the result of construction and continued operation of the CRS. Survival has improved for juvenile SR spring/summer Chinook salmon migrating through the CRS to the ocean as a result of past actions. Juvenile Chinook salmon survival has also improved in the estuary and tributaries due to habitat improvements implemented by the Action Agencies. For adult SR spring/summer Chinook salmon, survival is affected in the estuary up to Bonneville Dam by pinniped predators.

Cumulative effects from non-federal actions, and the effects of climate change and variable ocean conditions, have the potential to affect survival of SR spring/summer Chinook salmon. Land use activities (primarily private) have the potential to affect juvenile survival by decreasing tributary and estuary habitat or degrading abiotic factors, such as stream temperatures from urban, rural, and agricultural development and runoff. Further degradation of tributary habitat could also affect adult SR spring/summer Chinook salmon survival by reducing holding and spawning areas or development of passage barriers. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies implement fisheries that can have a direct effect on the number of returning Chinook salmon to the SR tributaries (and in some cases, within the tributaries themselves).

It is anticipated that survival gains resulting from previous actions will continue and possibly increase as a result of continuing tributary and estuary habitat actions. It is also anticipated that improvements to juvenile and adult passage conditions at the CRS dams will be maintained. For downstream migrating juveniles, it is anticipated that, not only will survival through the CRS improve, but ocean survival may increase as a result of fish entering the ocean with fewer powerhouse encounters during their downstream migration, should the latent mortality hypothesis be valid. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications to actions.

Travel Time

The building and operation of the CRS has slowed juvenile travel time compared to the pre-CRS condition, potentially increasing exposure to predators as they migrate through the CRS. Travel time within the tributaries and estuary are not affected by the existence or operation of the CRS. While travel time of juveniles within the CRS varies from year to year, actions from the past that are on-going send more fish through non-turbine routes, which is believed to decrease travel time and improve survival. Adult travel time is not considered an issue. However, increased water temperatures may lead to migrational delays at fishways, which may reduce spawning success.

Future non-federal actions are not expected to affect travel time of juveniles or adults through the CRS during any life stage. However, it is anticipated that projected increased air temperature due to climate change will likely continue to increase overall temperatures in the Columbia River and, therefore, have the potential to further affect adult SR spring/summer Chinook salmon upstream migrational timing and possibly juvenile emigration timing.

The Proposed Action is anticipated to reduce forebay resident time (a decrease in downstream time) for juvenile SR spring/summer Chinook salmon migrating past CRS dams during the flexible spill plan implementation. Continued monitoring of adult SR spring/summer Chinook salmon migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse Passage Proportion

Past and current physical modifications and operations of the CRS hydroelectric projects have increased the percentage of juvenile fish passing non-turbine routes. Decreasing powerhouse passage improves survival of juveniles during their downstream migration and provides a safer route of passage for adult migrants that overshoot their natal stream.

The effects from state and private actions are not anticipated to affect juvenile SR spring/summer Chinook salmon powerhouse passage.

The Proposed Action will continue implementing past improvements and actions that have resulted in increased non-turbine passage at the CRS projects. Additional powerhouse surface passage routes and upgraded adjustable spillway weirs at Lower Granite, Lower Monumental, Ice Harbor, McNary, and John Day dams will improve juvenile passage and offer greater range of operations of surface-oriented passage throughout the migration season. The Proposed Action will increase spill during the juvenile migration period, and that is expected to result in fewer powerhouse encounters for juvenile SR spring/summer Chinook during their downstream migration. Finally, as techniques and additional operations are considered, further increases in non-turbine passage could occur.

Total Dissolved Gas

Total dissolved gas has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high levels that resulted in GBT in juveniles and adults as they migrated through the CRS. Elevated TDG levels are not observed within tributaries or the estuary (where the effects of CRS operations on TDG are attenuated by distance and

tributary inflow). The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

Continued monitoring of juveniles and adults for signs of GBT will inform managers on the effects of this action.

It is anticipated that implementing the flexible spill program will elevate TDG levels, which may slightly increase the incidence of GBT in juvenile fish.

Temperature

Water temperatures have been modified as a result of a range of anthropogenic activities, including construction and operation of the CRS, throughout the Columbia River Basin. Increases in temperature can have a range of effects on both juvenile and adult SR spring/summer Chinook salmon.

On-going non-federal land management activities that affect temperature, such as agriculture, urban and rural development, and forestry, are not expected to change substantially during the period of this consultation. These activities, coupled with continued population growth in the region, will likely result in further degradations to the environment that influences water temperatures. However, small improvements may be realized from tributary actions that restore and preserve habitat, like riparian plantings.

Implementation of the habitat enhancement action component of the Proposed Action will continue to improve tributary temperatures but will continue to have minimal effect on mainstem temperatures.

Turbidity

Currently, sediment loads in tributaries have been affected by historical land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and rearing habitat. In the mainstem Columbia and Snake Rivers, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk.

In the tributaries of the Snake River, non-federal actions, such as urban, rural, and agricultural development, are likely to continue to affect turbidity; however, improvements in tributary habitat included in the Proposed Action are expected to result in reduced sediment inputs, resulting in modest, site-specific improvements that will mitigate continued non-CRS activities that degrade habitat. In the CRS, the current condition is not anticipated to change, and no non-federal activities are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment delivery levels from the tributaries. In the CRS, it is not anticipated that the Proposed Action will change the current condition.

Dam Passage (adults)

Currently, SR spring/summer Chinook salmon migrate upstream through CRS projects on their way to natal spawning areas and experience a variety of factors affecting them, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic

demands of migrating fish. Current adult passage conditions should improve with modifications at Bonneville and Lower Granite dams fishways, which should help reduce delay. Installation of pumping systems to provide cool water in adult fish ladders at Lower Monumental and Ice Harbor dams should also improve adult passage conditions within the CRS. SR spring/summer Chinook salmon appear to survive their migration through the CRS at high levels, and those survival rates are expected to continue with implementation of the Proposed Action. In addition, adult Chinook salmon that fallback at CRS projects should benefit from the flex spill program, because surface-oriented passage routes through the spillways should guide more adults away from powerhouse passage routes.

Non-federal actions that have the potential to affect SR spring/summer Chinook adults migrating through the CRS are unlikely. However, the continued degradation of tributary habitat that increases temperatures and projected increased air temperatures due to climate change that results in warming surface water temperatures indirectly influence migratory behavior in ways that slow or delay upstream migration and reduces survival and reproduction. The Proposed Action will continue to monitor adult migration through the CRS and use that information to propose specific actions that will increase adult survival.

Non-Operational

Predation

Currently, both juvenile and adult SR spring/summer Chinook salmon encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinniped predators prey on adults as they enter the Columbia River from the ocean to the tailrace of Bonneville Dam, often leading to the mortality of returning adult SR spring/summer Chinook salmon. A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS, mostly in the tailraces of dams. This predation accounts for a portion of juvenile mortality during migration through the CRS.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS operations have no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

The Proposed Action will continue to implement the predator management programs to limit SR spring/summer Chinook salmon mortality from environmental baseline conditions. This should ensure that predation-caused mortality does not increase and may reduce overall predation rates. Some impacts to SR spring/summer Chinook salmon will occur as a result of implementing the northern pikeminnow predation program but are considered minor.

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs and there are currently 18 spring/summer Chinook hatchery programs in the Snake River Basin. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to operation of hydro facilities, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin

Chinook salmon and their habitat depends on the design of hatchery programs, the condition of the habitat, and the status of the species, among other factors.

The majority of hatchery programs are run by the state in which they occur. It is anticipated that most of the current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue.

The Proposed Action includes continuation of the SR spring/summer Chinook salmon hatchery program in Johnson Creek. All hatchery programs in the Upper Salmon River have committed to strategies to limit hatchery straying and ecological interactions with ESA-listed natural-origin fish (NMFS 2019). Current hatchery programs will continue to be studied, and management agencies will make recommendations to reduce potential effects.

Habitat Actions

Habitat conditions in the tributaries, mainstem Columbia River, and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect SR spring/summer Chinook salmon include continued degradation of tributary habitat that increase temperatures and projected increased air temperature due to climate change that is warming surface water temperatures.

The Proposed Action will continue to rehabilitate the degraded baseline condition of habitat in the tributaries and estuary and, thereby, improve long-term survival of SR spring/summer Chinook salmon.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on SR spring/summer Chinook salmon. These are associated with the capturing and handling of fish. Research, monitoring, and evaluation activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no non-federal known RM&E actions anticipated that would affect SR spring/summer Chinook salmon.

The Proposed Action will continue to implement the RM&E programs that are currently occurring, with the potential to modify these programs in the future as the results of the monitoring programs are evaluated. While some individual SR spring/summer Chinook salmon are harmed, even killed, as a result of RM&E activities, the actual numbers are relatively small, and the information gained outweighs these minor losses.

Summary

In Table 3-26, the Proposed Action is compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action.

Most of the actions are anticipated to either have no effect, or a positive effect compared to the baseline condition (Table 3-26). This is partly because the Proposed Action continues numerous beneficial actions developed over the preceding decade, including habitat improvement, flow augmentation, and fish passage operations. Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-26. Summary comparison of the Proposed Action to current conditions for SR spring/summer Chinook salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Chinook Salmon Downstream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x	x	+	Continuation of predator management programs should decrease predation.
	Hatcheries	x	x	=	
	Predation monitoring	x	x	=	
	Fish status and trend monitoring	x	x	=	
Juvenile Chinook Salmon Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Chinook Salmon Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Chinook Salmon Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce overshoot.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
Fish status and trend monitoring		x	=		
Adult Chinook Salmon Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring		x	=	

3.1.3 Upper Columbia River Salmonid Species

The UCR region encompasses the Columbia River and its tributaries from McNary Dam upstream to Chief Joseph Dam, the limit of anadromy. Major tributaries included are the Wenatchee, Entiat, Methow, and Okanagan Rivers. Within the UCR region are two ESA-listed anadromous salmonids, UCR spring-run Chinook salmon, and ESU and UCR summer-winter steelhead trout DPS. This section summarizes information on UCR spring Chinook and UCR steelhead abundances and trends of these species (Figure 3-18).

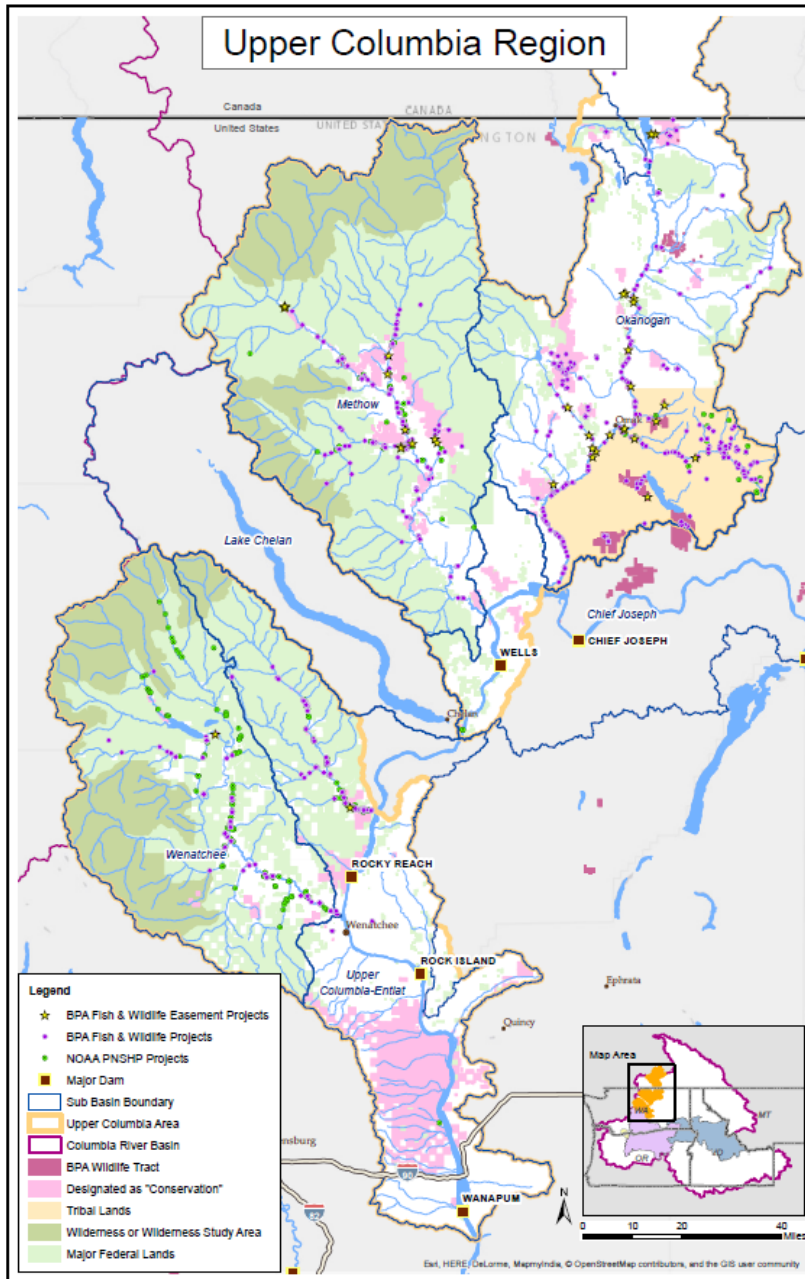


Figure 3-18. Upper Columbia River region, showing restoration actions relative to land ownership and conserved areas

Numerous anthropogenic influences associated with the settlement of the Pacific Northwest caused salmon and steelhead declines throughout the northwest, as well as UCR spring Chinook and steelhead declines in the UCR region. The Wenatchee, Methow, Entiat, and Okanogan Rivers were historically

excellent salmonid producing rivers, but were virtually decimated in the early 1900s¹¹ (Fish and Hanavan 1948). For example, the Washington Department of Fisheries reported that in 1935 (prior to construction of any FCRPS dams) only ten Chinook (without differentiation between spring and summer) were counted over the ladder at Tumwater Dam in the Wenatchee River; there were only five fish counted in 1936 and four in 1937 (WDF 1938). The conclusion was:

It is very evident from the above figures that the chinook [sic] runs above Tumwater Dam are practically wiped out and the blueback run is not in much better shape. (WDF 1938).

Irrigation and water power developments in these tributaries (unrelated to the CRS or Reclamation Projects) were considered the principle cause of the decimated runs (WDF 1938).

The Upper Columbia Recovery Plan lists the factors for salmon and steelhead decline as the following: social, cultural, and economic factors, public policy, management actions, harvest, hatcheries, hydropower, habitat, ecological factors, factors outside the ESU and DPS, and interaction of factors (UCSRB 2007). The UCR Plan further discusses the factors for decline in more length, quoting Lackey (2003), who succinctly summarized the decline of all salmon and steelhead as follows:

The depressed abundance of wild stocks was caused by a well-known but poorly understood combination of factors, including unfavorable ocean or climatic conditions; excessive commercial, recreational, and subsistence fishing; various farming and ranching practices; dams built for electricity generation, flood control, and irrigation, as well as many other purposes; water diversions for agricultural, municipal, or commercial requirements; hatchery production to supplement diminished runs or produce salmon for the retail market; degraded spawning and rearing habitat; predation by marine mammals, birds, and other fish species; competition, especially with exotic fish species; diseases and parasites; and many others. Technocrats continue to vigorously debate what proportion of the decline is attributable to which factor.

Upper Columbia spring Chinook and steelhead pass through four of the CRS dams in the lower Columbia River. These fish also pass Columbia River mainstem dams not related to the CRS or this consultation. Wenatchee fish pass through an additional three private hydroelectric dams (seven total dams), Entiat fish pass through one more (eight total dams), and Methow fish must pass one more additional dam (nine dams total).

Efforts to date by the Action Agencies to improve UCR spring Chinook and steelhead populations include passage improvements for both adults and juveniles, enhancement of spawning and rearing tributary habitat, and conservation of flows in areas where there are no CRS facilities.

Specific CRS mitigation for UCR spring Chinook and steelhead in this geographic area has included:

¹¹ "The earliest identified negative human impact was fishing. Early harvest focused on chinook; when the chinook harvest declined after 1884, emphasis shifted to steelhead and sockeye (1890-1900), followed by chum and coho (1920s). By 1945, all species had declined significantly." P 97 NPPC 1986.

- Annual flow augmentation during the juvenile salmon and steelhead spring migration.
- Extensive modifications to McNary, John Day, The Dalles, and Bonneville Dams and associated fish facilities to improve passage, including provision of surface passage.
- Significant alterations to system operations to help support these species, including spill.
- Spill deflectors at Chief Joseph Dam and the Lower Columbia mainstem dams, combined with system operations to help manage TDG.
- An extensive tributary and estuary habitat improvement effort with ongoing benefits from past actions.
- Predator management, including piscivorous fish, avian, and pinniped predation control measures.
- To the extent possible, dam maintenance activities that could affect flow are scheduled outside the spring migration period.

As reported in the 2016 Comprehensive Evaluation, one measure of the past level of effort associated with tributary habitat improvements in the Wenatchee, Entiat, and Methow is shown below (Figure 3-18 and Table 3-27.) (Corps et al. 2017a). Most of these projects will continue to benefit salmon and steelhead in these basins into the future, and the cumulative result is improving both habitat capacity and quality (Bonneville and Reclamation 2013; Roni et al. 2014).

Table 3-27. Cumulative habitat improvements for UCR spring-run Chinook and steelhead from 2007 to 2015 (Corps et al. 2017a)

Habitat Improvement Metric	UCR Spring Chinook ¹²	UCR Steelhead ¹²
Acre-feet/year of water protected	23,708.8	39,908.6
Acres protected and treated	640.1	1685.0
Miles of enhanced or newly accessible habitat	110.4	201.0
Miles of improved stream complexity	21.8	28.2
Miles protected	8.32	11.2
Screens installed or addressed	10	82

3.1.3.1 Upper Columbia River Steelhead DPS

This section examines the status of the UCR steelhead, the status of UCR steelhead critical habitat, and the effects of the Proposed Action on UCR steelhead.

¹² The metrics associated with habitat actions that benefit both Chinook and steelhead in the same basin are included in the rows for both species. For instance, the 82 “Screens installed or addressed” for steelhead include the 10 installed specifically for Chinook.

STATUS OF THE UCR STEELHEAD DPS

The UCR steelhead DPS was first listed under the Endangered Species Act in 1997, at which time it was classified as an endangered species (62 FR 43937). Since then, the UCR steelhead designation has undergone several re-classifications. On January 5, 2006, the UCR steelhead was reclassified as a threatened species (71 FR 834). On June 13, 2007, the U.S. District Court for the Western District of Washington ruled that NMFS had erred in that downlisting, which resulted in the DPS being returned to endangered status. NMFS appealed that ruling; the U.S. Court of Appeals for the Ninth Circuit ruled that the downlisting had not violated the ESA, and on August 24, 2009, the status was changed back to threatened (74 FR 42605). On April 14, 2014, the status designation of threatened was reaffirmed (79 FR 20802), and after the 5-year review of the DPS, NMFS concluded that the UCR steelhead should remain listed as a threatened species (NMFS 2016b). Critical habitat was designated on September 2, 2005 (70 FR 52630).

The UCR steelhead DPS range extends from the Yakima River upstream to natural and anthropogenic barriers within the Columbia River Basin to the United States/Canada border (Figure 3-19; NOAA Fisheries 2019). In addition to the four extant populations (the Entiat, Wenatchee, Methow, and Okanogan populations), the ICTRT designated six populations in two MPGs in areas historically occupied but blocked by the construction of Chief Joseph and Grand Coulee Dams. Seven of the 10 populations in the UCR were extirpated decades before enactment of the ESA and are not included in the species definition. In addition to the naturally spawning populations, the MPG consists of six artificial propagation programs (Table 3-28.).

Table 3-28. Summary of extant major population groups (MPGs) within the UCR steelhead DPS, including artificial production programs for UCR steelhead

Major Population Group	Populations
Natural Production	
Wenatchee/Methow	Wenatchee River, Entiat River, Methow River, and Okanogan River. Crab Creek – Functionally Extirpated
Artificial Production	
Hatchery Programs included in DPS (n = 6)	Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop National Fish Hatchery (NFH), Omak Creek, and Ringold.

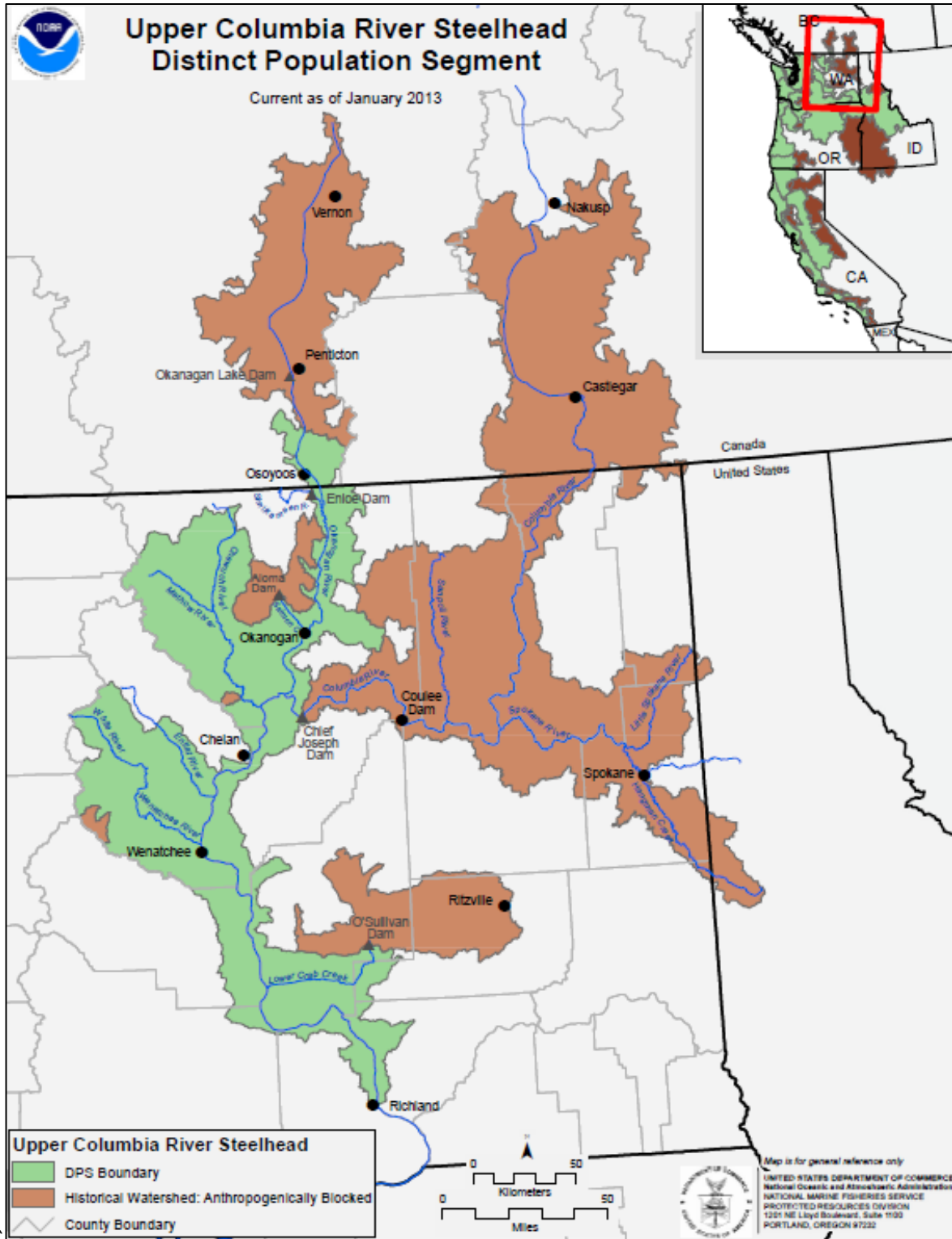


Figure 3-19. Map of the UCR steelhead DPS spawning and rearing areas, illustrating natural populations and both extant and historical MPGs. (Source: NOAA Fisheries website accessed 10-10-19: https://archive.fisheries.noaa.gov/wcr/publications/gis_maps/maps/salmon_steelhead/esa/steelhead/ucr_steelhead.pdf).

Steelhead that originate in the Wenatchee River Basin must pass a total of seven hydroelectric projects as they descend through the mainstem Columbia River as juveniles and during upstream migration as adults. Those hydroelectric projects include the four lower CRS projects (i.e., Bonneville, The Dalles, John Day, and McNary Dams) and three projects owned and operated by Grant County Public Utility District (PUD) (Priest Rapids and Wanapum Dams) and Chelan County PUD (Rock Island Dam). The Entiat River population must pass those projects, as well as Rocky Reach Dam (a Chelan PUD project). The Methow and Okanogan populations must pass a total of nine projects: the projects identified above, as well as Wells Dam, which is owned and operated by Douglas County PUD.

In the most recent 5-year status review of UCR steelhead (NWFSC (Northwest Fisheries Science Center) 2015), NMFS concluded that UCR steelhead numbers have increased relative to what was observed throughout the 1990s. In addition, they noted recent estimates of abundance and productivity for natural-origin fish for all four populations within the DPS show fairly consistent patterns throughout the years. However, abundance and productivity for the Entiat, Methow, and Okanogan populations were well below the viability threshold (NMFS 2019).

(NMFS 2019) also concluded that the current risk of extinction for the UCR steelhead is primarily driven by low abundance and productivity, as well as a lack of genetic diversity and the high level of hatchery spawners among natural-origin spawners. Based on their assessment of the abundance, productivity, spatial structure, and diversity of UCR steelhead, NMFS concluded that overall viability rating of high risk for the Entiat, Methow, and Okanogan populations; only the Wenatchee population was classified as maintained [see Table 2.10-2 in (NMFS 2019)]. Based on their overall findings, (NMFS 2019) concluded that (NMFS 2019) also concluded that the current risk of extinction for the UCR steelhead is primarily driven by low abundance and productivity, as well as a lack of genetic diversity and the high level of hatchery spawners among natural-origin spawners. Based on their assessment of the abundance, productivity, spatial structure, and diversity of UCR steelhead, NMFS concluded that overall viability rating of high risk for the Entiat, Methow, and Okanogan populations; only the Wenatchee population was classified as maintained [see Table 2.10-2 in NMFS (2019)]. Based on their overall findings, (NMFS 2019) concluded that

... the overall DPS status of high risk remains unchanged from the prior review, driven by low abundance and productivity relative to viability objectives and diversity concerns. The required improvements to improve the abundance/productivity estimates for the UCR steelhead populations are at the high end of the range for all listed Interior Columbia DPS populations (NWFSC (Northwest Fisheries Science Center) 2015).

FACTORS AFFECTING THE STATUS OF UCR STEELHEAD

Within the UCR tributaries that support the spawning and rearing of UCR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Anthropogenic activities, e.g., agriculture, forestry practices, and human development have degraded habitat; impaired fish passage; decreased floodplain connectivity, channel structure, function, and complexity; and reduced riparian area, large woody debris recruitment, streamflow, and water quality (NMFS 2019). Additional factors also affect

UCR steelhead status, such as genetic diversity effects from out-of-population hatchery releases, predation, adverse mainstem Columbia River hydropower-related effects, degraded ocean conditions, and harvest (NMFS 2019).

With a decline in salmonid production, and as a result a decline in spawners within natal streams, nutrients vital to juvenile production have also decreased dramatically. Gresh et al. (2000) estimated that since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only about 6 to 7 percent of historical levels. They attributed this decline to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. These nutrients are important for salmonid production, and consequently for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2002).

Over a total life cycle, the greatest incidence of mortality occurs where UCR steelhead spend most of their life, i.e., tributary and ocean environments (see Section 3.2.1.1, Figure 3-1). Tributary survival of juvenile steelhead varies depending on habitat and climate conditions and the carrying capacity of the natal stream (Thurow 1987; Chapman et al. 1994). Within tributary habitat, egg-to-emigrant survival for UCR steelhead averages 1.1 percent (Maier 2014). Smolt-to-adult survival has been measured for two of the UCR steelhead populations; for Wenatchee hatchery steelhead, it averaged 0.91 percent for years 1998–2010 (Hillman et al. 2019), and 1.4 percent for Methow River steelhead (Snow et al. 2018).

Widener et al. (2019) compiled estimates of survival for juvenile steelhead migrating downstream through the Snake and Lower Columbia rivers. Survival estimates represented empirical estimates for specific geographic reaches, which, depending on the area of inference, could be from the forebay to the tailrace of a specific dam (dam passage survival), or from one dam (e.g., tailrace of McNary Dam) to another dam (e.g., tailrace of Bonneville Dam) (reach survival). Estimates for UCR steelhead for the reach from McNary Dam to Bonneville Dam averaged 0.77 from 2003–2018 (see further discussion below). Next, we discuss by life-stage factors affecting the status of UCR steelhead.

Freshwater Spawning, Rearing, and Migration to the CRS

UCR steelhead use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. While many of the habitat modification are relics of past anthropogenic practices, NMFS identified factors limiting viability in the UCR in tributary areas that continue to influence productivity. The 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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition. Human activities (threats) 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 (NMFS 2019).

The consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. As noted above (Section 3.2.1), the ISAB (2015) provided evidence for strong density dependence at current abundance levels for anadromous salmon and steelhead and suggests that habitat capacity has been greatly diminished. Density dependence was observed in most rivers where data have been examined and includes 26 of 28 interior Columbia Basin Chinook salmon populations,

and all 20 interior Columbia Basin steelhead populations despite natural spawners being much less abundant currently relative to historical abundance (2015).

In an assessment of density dependence using a two-stage Gompertz model, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages. They found that due to density dependence during the parr-to-adult stage, a greater number of fish reaching the ocean may not substantially increase the number of adults reaching the spawning grounds. Based on this evidence, the authors concluded:

This suggests that life cycle modeling to date has been overly optimistic about the benefits of survival rate increases in the hydrosystem and elsewhere to improve the viability of salmon populations threatened with high extinction risk.

While the modeling framework of Hinrichsen and Paulsen (2019) was applied to SR spring/summer Chinook, the results are consistent with the 2015 ISAB report and therefore, it is reasonable to assume that UCR steelhead are also experiencing similar effects of density dependency.

Past and present effects of the existence of CRS dams and operations: UCR steelhead are not exposed to the CRS facilities or operations during adult holding, spawning, egg incubation, and juvenile rearing and migration within the tributary environment.

Past and present effects of hatcheries: Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They can also help preserve genetic resources until factors limiting natural productivity 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.

NMFS (2019) concluded that current risk to the UCR steelhead DPS from hatchery programs is driven by 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. However, recent changes in hatchery practices in the Wenatchee River appear to have reduced hatchery contributions or increased spatial separation of hatchery—and natural—origin spawners, which could strengthen the influence of natural selection over time.

Hatchery programs operated within the UCR steelhead DPS, including the Wenatchee, Methow, and Okanogan River Basins, also create some risks due to ecological interactions and genetic introgression. All hatchery programs for steelhead in the UCR incorporate natural-origin adults into the broodstock and NMFS has determined that these hatchery programs have not changed substantially, or in a way to suggest that their level of divergence relative to the local population differs from what would be expected between closely related natural populations within the DPS (Jones 2015).

Juvenile UCR Steelhead Downstream Migration Through the CRS

All UCR steelhead populations pass the four lower CRS dams on their downstream migration.

Past and present effects of CRS existence and operations: Through the CRS, juvenile UCR steelhead have been and continue to be exposed to the effects of both CRS operations and the existence of the CRS

dams. Juvenile UCR steelhead pass downstream of dams by many routes, including spillways and surface passage structures, intake screen bypass systems, and turbines. Major modifications have been made to projects within the CRS to improve survival and achieve the 2008 BiOp juvenile dam passage performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project (Table 3-29).

Table 3-29. Average fish passage efficiency and dam passage survival estimates for juvenile steelhead passing CRS dams [based on Table D-1 and D-2 from Bonneville et al. (2018a)].

Dam	Year of studies	FPE	Year of studies	Average survival estimate
Bonneville	NA	NA	2010, 2011	97
The Dalles	NA	NA	2010, 2011	97
John Day	2012	97	2011, 2012	98
McNary	2012, 2014	93	2012, 2014	98

Modifications of the dams included the installation of surface passage systems, improved turbine designs, and upgrades of outfalls for turbine intake screen bypass systems to improve how and where fish are returned to the river downstream from dams, as well as new spill operations tailored to the unique structural configuration of each dam (Bonneville et al. 2017). A summary of those improvements is provided in Appendix A of Bonneville et al. (2017) and is incorporated by reference here. Briefly, actions shown to have benefited UCR steelhead include the following:

- Minimize winter drafts of the large upper basin storage reservoirs (for flood risk management and power generation) to save water for augmenting spring flows during the peak juvenile passage period (water quantity).
- Employ JBSs and surface passage structures and provide spill at the run-of-river dams to divert smolts away from turbine units and reduce potential delay in the forebays and minimize predation (safe passage).
- Install replacement turbines with biologically based designs for safer fish passage than the case for the original units.
- Reduce TDG through multiple actions and plans.
- Manage avian and fish predators through multiple actions and plans.

For hatchery juvenile UCR steelhead cohort years 2003 to 2018, from MCN to BON, reach survival rates averaged 0.77 (Widener et al. 2019). However, if these estimates are broken into specific time periods, the average reach survival estimate from McNary Dam to Bonneville Dam for years 2003 through 2007 (there were no estimates in 2008) was 86 percent, while from 2009 through 2018, survival increased to 91 percent (Widener et al. 2019).

Because the survival of fish passing the dams via non-turbine routes is higher than through turbines, passage facilities are designed and operated to increase the likelihood of juvenile fish passage through non-turbine routes. The metric by which this is measured is FPE. Depending on the location and time of year, greater than 90 percent of juvenile steelhead use non-turbine routes at the four lower Columbia River dams (Bonneville et al. 2017) (see Table 3-29).

As discussed previously, Widener et al. (2019) compiled estimates of survival for juvenile steelhead migrating downstream through the Snake and lower Columbia Rivers. However, those estimates included data for years preceding major physical and operational modifications to the CRS, and therefore the estimates of survival do not fully express the benefits realized by those modifications. Following structural and operational modifications implemented after the 2008 BiOp, survivorship improved through the CRS (Bonneville et al. 2017). While no studies have been completed to infer what caused the increase in survival since 2009, the timeframe is consistent with the implementation of operational structural modifications undertaken specifically to improve downstream survival. The increase in mean annual survival estimates for 2007–2018 from 1980–2001 (Figure 3-4) suggests that the structural and operational changes at the dams since 2009 are working to increase UCR steelhead survival during outmigration.

In addition, elevated TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can get forced into solution when water passes over the spillway at a mainstem dam, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019). Because UCR steelhead are susceptible to GBT, they benefit from the gas abatement structures.

Past and present effects of predator management: Survival of UCR juvenile steelhead is affected by avian and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple 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. These efforts have reduced avian and piscivorous predation on juvenile salmon and steelhead at the dams, including UCR steelhead (NMFS 2019).

Juvenile UCR Steelhead Estuary Migration and Rearing, Including the Plume

The estuary provides important habitat for UCR steelhead populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also impacted estuary ecosystems. For a more detailed discussion of estuary and plume conditions, see (NMFS 2019). All these conditions are part of the environmental baseline.

Past and present effects of CRS existence and operations: While there are no CRS facilities in the estuary (defined as Bonneville Dam to the ocean), the existence and operation of the CRS have affected the timing and volume of flows, temperature, sediment load, and TDG levels in this area. These effects generally decrease as distance from Bonneville Dam increases and estuary hydrodynamics become less fluvially influenced. In particular, flow regulation from operations and reduced sediment recruitment the

existence of the CRS have likely negatively affected habitat forming processes in the estuary, habitats which support the juvenile life stage of all Columbia River Basin anadromous fish populations.

Estuary floodplain habitat is important for out-migrating juvenile salmon and steelhead, including UCR steelhead. To help maintain and improve the overall status of salmon and steelhead in the Columbia River Basin, the Action Agencies actively work to restore and conserve habitat in the Columbia River estuary through the CEERP. These restoration actions affect salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit of estuary restoration is that wetland food production supports foraging and growth within the wetland [Johnson et al. (2018) as cited in NMFS (2019)]. Prey items (primarily chironomid insects and corophiid amphipods; [PNNL/NMFS (2018) as cited in NMFS (2019)]) produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest 5-year review of the CEERP (Johnson et al. 2018), have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity below Bonneville Dam [Johnson et al. (2018) as cited in NMFS (2019)]. In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past and present effects of predation management: A variety of avian species (especially Caspian terns and double-crested cormorants) have historically been a major source of predation on juvenile salmonids in the estuary, as noted in Section 3.2.1. While avian predators continue to prey upon juvenile salmonids, including UCR steelhead, predation rates have declined due to a variety of management efforts. For example, the average predation on UCR steelhead by Caspian terns from East Sand Island (in the lower estuary) was approximately 17% from 2000 and 2010 (Evans et al. 2018). For Double-crested cormorants, the average for years 2003–2015 was 5.1%. These two time periods represent the “pre-management period.” However, after management actions have taken place (after 2010 for terns and 2015 for cormorants), the average predation by terns on UCR steelhead dropped to 9.0%, and there are no estimates for the management period because of low sample sizes for Double-crested cormorants (Evans et al. 2018). The efforts to reduce avian predation are discussed in detail within the 2019 BiOp and are incorporated by reference here (NMFS 2019). NMFS (2019) noted the success of implementing the avian management plans at meeting underlying goals; however, the results may be uncertain at this time because some cormorants and terns have relocated to other areas within the estuary.

Ocean Rearing

UCR steelhead typically spend 1 to 2 years rearing in the ocean (NMFS 2009). Variability in marine ecosystem productivity can be a major factor in determining adult steelhead run size (NMFS 2014a). Since about 2014, poor ocean conditions have contributed to declines in ocean survival and associated adult returns. In the 2019 BiOp, NMFS provided a detailed discussion on ocean conditions, factors that affect the ocean environment, and impacts to UCR steelhead. That information is incorporated here by reference; a brief summary follows.

Factors that influence ocean conditions are also likely to affect survival of UCR steelhead. The consequences of climate change will likely include increased water temperatures, more severe El Niño events, worsened ocean acidification, and major alterations in the northeast Pacific Ocean marine ecosystem associated with the Pacific Decadal Oscillation (NMFS 2019). These factors will affect UCR steelhead survival either directly or indirectly because of their deleterious impacts on marine food webs.

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in distribution of aquatic marine organisms. Many species that typically occur in more southerly waters, moved northward from southern California to Alaska in the unusually warm water during 2014 and 2015, which was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Pearcy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt marine ecosystems in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean, and past CRS operations have had no direct effect on this DPS during ocean residence. Welch et al. (2018) concluded that marine survival of west coast Chinook and steelhead populations has collapsed over the last half century for most regions of the west coast. Based on their review of annual survival estimates for Chinook and steelhead, they concluded the following:

We found that marine survival collapsed over the past half century by a factor of at least 4–5-fold to similar low levels (~1%) for most regions of the west coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Past and present effects of harvest: Harvest of steelhead in the ocean is rare (NMFS 2019).

Adult UCR Steelhead Migration to Bonneville Dam

Adult steelhead migrating upstream after ocean residence typically do not feed within the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume, and a migratory corridor free of obstructions to access spawning areas (NMFS 2019). Populations of UCR steelhead enter the Columbia River estuary and pass over Bonneville Dam in July; most migrants are observed from mid-July through the end of August, with peak migration in early August (Keefer et al. 2016).

For upstream migrating UCR steelhead, the primary factor affecting survival to Bonneville Dam is pinniped predation. Estimates of pinniped predation downstream of the Bonneville Dam tailrace are not available for adult steelhead from any DPS, although salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019).

The ODFW has documented an increase of monthly counts of California sea lions hauling out at the East Mooring Basin in Astoria, Oregon during the month of September. For the years of 2008 to 2014, the number of California sea lions observed averaged less than 500 animals; for 2015 and 2016, that average increased to more than 1,000 individuals (NMFS 2019).

The abundance of pinnipeds in the Bonneville Dam tailrace has increased over the last 6 years (Tidwell et al. 2018). In a subsequent study, Tidwell et al. (2018) documented an average of 14.5 Stellar sea lions between July 21 and December 31, 2017 and on numerous occasions, observed more than 20 individuals. Based on adjusted consumption rates, Tidwell et al. (2018) estimated a consumption rate of 1.54 percent for all steelhead collectively. Average pinniped impacts to summer migrating adult UCR steelhead are likely relatively small because pinniped counts are generally low in July and August (when most UCR steelhead pass Bonneville Dam) and they are mixed with relatively abundant fall Chinook salmon migrating in September and October (NMFS 2019).

Past and present effects of CRS dams and operations: There are no CRS dams or operations that impede migration in the Columbia River estuary upstream to Bonneville Dam. As previously mentioned, adult UCR steelhead enter the Columbia River from July through September, and the Action Agencies are required to spill water over the CRS dams to increase survival of juvenile fish migrating downstream during a large portion of that time. As such, adults may be exposed to higher levels of TDG, which may influence their migration behavior or increase their chances of GBT (NMFS 2019). TDG levels are mitigated to some extent downstream from Bonneville Dam due to gas dissipation and to mixing of water with lower TDG levels from tributaries downstream of Bonneville Dam.

Past and present effects of harvest: Harvest mortality in fisheries downstream of Bonneville Dam have been reduced substantially in response to evolving conservation concerns and restrictions for ESA-listed species. Historically, UCR steelhead were harvested in both non-treaty commercial fisheries, as well as in recreational fisheries in the area downstream of Bonneville Dam to the mouth. In response to declining steelhead abundance, non-treaty commercial harvest of steelhead was prohibited in 1975, and treaty commercial harvest has been reduced and restricted to clipped (hatchery-origin) fish. As such, the harvest of non-clipped fish is incidental. Also, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986.

Adult UCR Steelhead Migration Through CRS Dams

UCR steelhead populations migrate upstream through all four lower CRS projects and three to five PUD projects on their way to natal spawning areas. During upstream migration, these fish experience a variety of factors, such as harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish [NMFS (2008b); Keefer et al. (2016); and Keefer and Caudill (2017) as cited in NMFS (2019)]. The primary factors influencing safe, timely, and effective adult upstream passage through CRS dams are tailrace flow dynamics, sufficient attraction flows to fish ladder entrances, operating ladders within criteria, reducing fallback, and maintaining safe ladder temperature and differentials (NMFS 2019).

Past and present effects of CRS existence and operations: Under typical conditions, after accounting for reported harvest rates and expected stray rates, adult UCR steelhead have relatively high conversion rates¹³ passing the lower CRS dams (NMFS 2019). The 10-year average minimum survival estimates for

¹³ Conversion rates are simply the percentage of adult salmonids passing an upstream dam that passed a downstream dam ($\frac{\# \text{ passing}_{\text{upstream dam}}}{\# \text{ passing}_{\text{downstream dam}}}$). Conversion rate is used as a surrogate for survival,

UCR steelhead from Bonneville Dam to McNary Dam is 92.1 percent (range of 87.6 to 96.8 percent) (NMFS 2019).

These estimates of minimum survival also account for impacts associated with fallback at CRS projects, such as direct and indirect mortality associated with the fallback event, delay, straying, etc. The mean annual fallback rate at lower Columbia River dams is about 6 to 9 percent [Keefer et al. (2016) as cited in NMFS (2019)]. Based on the relatively high survival estimates, NMFS concluded that upstream passage conditions for adult UCR steelhead are not substantially impaired as fish migrate through impounded reaches of the lower Columbia River (NMFS 2019).

Each year, when the mainstem Columbia River temperature increases to above 64°F in the summer months, an unknown portion of UCR steelhead (including 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 (NMFS 2019).

Past and present effects of predator management: As discussed previously, the presence of pinniped predators has increased within the Bonneville Dam tailrace in recent years, with occasional pinniped observations in the Bonneville reservoir when UCR steelhead are present [Tidwell et al. (2018) as cited in NMFS (2019)]. To restrict entry of pinnipeds into the ladder systems at Bonneville Dam, the Corps constructed structures to physically exclude pinniped entry into fishways, while allowing upstream migration of adult salmonids. These structures have been installed at all eight fishway entrances at Bonneville Dam (NMFS 2019).

Average pinniped impacts to summer migrating adult UCR steelhead are likely relatively small because pinniped counts are generally low in July and August (when most UCR steelhead pass Bonneville Dam) and they are mixed with relatively abundant fall Chinook salmon migrating in September and October (NMFS 2019).

Past and present effects of harvest: Steelhead in the lower Columbia River above Bonneville Dam are primarily harvested during what managers term the “fall season.” During this period, fisheries target primarily harvestable hatchery and natural-origin fall Chinook and coho salmon and hatchery steelhead. Fall season fisheries are constrained by specific ESA-related harvest rate limits for listed SR fall-run Chinook salmon and for both A-Index and B-Index components of the listed UCR and SR steelhead DPSs.

A-Index summer steelhead are caught in summer sport fisheries downstream of Bonneville Dam and during fall through the following spring season fisheries upstream. Non-treaty fisheries are subject to a 2% harvest rate limit for A-Index summer steelhead in summer (from July 1 through July 31) and then from January 1 through the following spring since these are the same run of steelhead that have now migrated upstream in the Columbia River Basin. The total annual harvest rate limit for A-Index summer steelhead is 4 percent. The incidental catch of winter steelhead in non-treaty across all fisheries has averaged 1.9 percent since 2008. The yearly incidental catch of A-Index summer steelhead in non-treaty fisheries has averaged 1.9 percent since 2008 compared to the 4 percent yearly combined limits.

but other factors (than mortality) may affect the number of adult fish passing the upstream dam (e.g., tag not detected), so a conversion rate is not specifically an accurate measure of survival.

Harvest rates are not expected to change over the course of the 2018 *US v OR* Agreement (U.S. v. Oregon 2018).

There are no specific incidental harvest rate limits for treaty fisheries on the UCR Steelhead DPS. The BiOp for the *U.S. v Oregon* on-going process expects incidental harvest impacts on the winter steelhead stock and A-Index surrogate components for the UCR steelhead DPS associated with treaty tribal fisheries to be the same as the range observed in earlier years, between 1.4 percent and 6.9 percent for the winter steelhead stock and 4.6 percent and 12.9 percent on the A-Index stocks (U.S. v. Oregon 2018). However, the expected incidental harvest impacts on the winter stock and A-Index components of the UCR Steelhead DPS in treaty fisheries are expected to be less. The harvest rate for treaty fisheries on the winter steelhead stock in the Bonneville Pool from 2008 to 2017 averaged 0.5 percent and ranged from 0.1 percent to 1.4 percent. The harvest rate for treaty fisheries on the unclipped A-Index stock in the Bonneville Pool from 2008 to 2017 averaged 1.6 percent and ranged from 0.7 percent to 7.0 percent during the summer and subsequent winter/spring combined seasons and averaged 6.5 percent and ranged from 4.0 percent to 10.0 percent during the fall seasons (U.S. v. Oregon 2018).

Adult UCR Steelhead Migration Upstream of the CRS to the Spawning Areas

Within the upper Columbia River tributaries that support the spawning and rearing of UCR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

Low flows and high summer temperatures in tributary habitats can effectively create temporary migration barriers that reduce access to spawning habitat until conditions improve. These impacts to water quality in tributary habitat can affect the run timing and survival to natal spawning areas for adult UCR steelhead.

Past and present effects of harvest: Recreational fisheries for steelhead in UCR tributaries and mainstem Columbia River upstream of the CRS result in incidental impacts to natural-origin fish to some unknown degree. Of the fish that are caught and released, the assumption is that 10 percent will die from handling-related injuries (NMFS 2019).

Adult UCR Steelhead Downstream Passage (Kelts)

Anadromous steelhead in the Columbia River have multiple life history strategies including iteroparity. Iteroparity involves the downstream migration of post spawned steelhead (kelts) that return to the ocean or estuary environments for a period of time before spawning again. Kelt returns can be affected by the extreme energetic demands of spawning and iteroparity, harvest (which may affect spawn timing and location), and the Columbia Basin Hydrosystem (Colotelo et al. 2014). Most studies of adult survival carried out at Columbia River dams have used overwintering summer run steelhead (Khan et al. 2009; Ham et al. 2012a, b; Khan et al. 2013); hence, CRS related mortality specifically for downstream

migrating kelts is not as well-known at this time. The Corps conducted a direct survival test of adult steelhead passing through McNary dam in 2014; mean survival rates were 97.7% through the spillway weir route, and 90.7% via the turbine route for overwintering adults presumed to be in good condition (Normandeau 2014). As part of a two year study, Colotelo et al. (2013) estimated that 45% of SR steelhead kelts survived from the Lower Granite forebay to the Bonneville dam face (RM 234) and 41 percent of the lower Columbia River (LCR) (RM156), respectively. An estimated 67% of kelts survived from the McNary forebay to the Bonneville Dam face (Colotelo et al. 2013). River conditions were warmer with lower flow in the second year of the study in 2013; mean survival rates between Lower Granite Forebay and the lower Columbia River were somewhat lower (approximately 27%) and rates of travel were slower (Colotelo et al. 2014). In both years, smaller sized steelhead had better rates of survival; it was uncertain whether this resulted from a higher rate of injuries to larger bodied steelhead in dam passage routes, or whether larger fish were in poorer post-spawn condition.

STATUS OF CRITICAL HABITAT

In this section, the status of critical habitat and factors affecting it are reviewed for UCR steelhead. Critical habitat includes the stream channels within designated stream reaches and to an extent is defined by the ordinary high-water mark (33 CFR § 319.11). The PBFs of critical habitat that are essential to the conservation of UCR steelhead have been identified and include freshwater spawning, rearing and migration corridors, as well as estuarine and nearshore marine areas (Table 3-30) (NMFS 2019).

Critical habitat for the UCR steelhead DPS was designated on September 2, 2005 (70 FR 52630). Critical habitat for UCR steelhead was designated in the following watersheds (including major tributaries): Wenatchee River, Entiat River, Methow River, Okanogan River, and the mainstem Columbia River.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation 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 UCR steelhead.

All steelhead spawn in gravel and cobble substrates that are largely free of fine sediments. Developing eggs require cool, clean, and well-oxygenated waters for proper development. Juvenile UCR steelhead usually spend 2 years in freshwater but may remain longer (up to seven years; (Peven et al. 1994), depending on water temperature and growth. Juvenile migration to the ocean occurs during the spring freshet during the months of March through mid-June (NMFS 2019).

During their freshwater residence, juvenile salmonids need abundant food sources and instream cover to protect them from predators. Juvenile fish cover may include undercut banks, overhanging vegetation, logs and root wads, and large substrate (NMFS 2019). Off-channel habitat, side channels, and other low stream velocity areas provide refuge during high flow event. Cool waters offered by springs, seeps, and deep pools offer refuge when stream temperature increases during the summer. Interstices offered by large substrate allow juveniles to seek refuge during the winter.

Table 3-30. Physical and biological features and components and principal factors affecting the environmental baseline of critical habitat designated for UCR steelhead [Reproduced from NMFS (2019)]

Physical and Biological Features (PBFs)	PBF Components	Principal Factors Affecting Environmental Baseline Condition of PBFs
Freshwater spawning sites	Water quantity and quality conditions and substrate supporting spawning, incubation, and larval development	<p>Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage)</p> <p>Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage)</p> <p>Diminished streamflow (degraded water quantity, elevated temperatures, loss of juvenile and adult mobility)</p> <p>Impaired fish passage (obstructions, water withdrawals)</p> <p>Excess fine sediment in spawning gravel (degraded water quantity)</p> <p>Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation)</p>
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 supporting juvenile development, natural cover.	<p>Impaired fish passage (obstructions, water withdrawals)</p> <p>Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations)</p> <p>Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)</p> <p>Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage)</p>
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	<p>Delay and mortality of some juveniles and adults at up to five PUD-owned and four CRS dams on the mainstem Columbia River</p> <p>Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human built structures used by terns and cormorants for nesting)</p>
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity and salinity, natural cover, juvenile and adult forage	Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage) and the presence of toxic contaminants (reduced water quality and forage).
Nearshore marine areas ^a	Free of obstruction and excessive predation, with water quality, quantity and forage.	Concerns about increased opportunities for pinniped predators and adequate forage

Physical and Biological Features (PBFs)	PBF Components	Principal Factors Affecting Environmental Baseline Condition of PBFs
Offshore marine areas	Not designated	

^a The designated nearshore marine area includes only the mouth of the Columbia River, an imaginary line connecting the outer extent of the north and south jetties.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of UCR steelhead. Spawning and rearing occurs in the Wenatchee, Entiat, Methow, and Okanogan subbasins.

The quality of tributary habitat for UCR steelhead varies substantially throughout the UCR region with some spawning and rearing habitat in near pristine condition, while other areas are minimally to highly degraded due to past human activities (NMFS 2019). Habitat throughout the interior Columbia River Basin tributaries has been degraded by numerous human activities, including 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, timber harvest, mining, and urbanization [Lee et al. (1997) as cited in NMFS (2019)]. These activities have led to factors that limit the viability of UCR steelhead. These factors include (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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel instability are common symptoms of ecosystem decline in areas of critical habitat. Lack of adequate summer streamflows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas of the interior Columbia Basin. Large-scale habitat assessments in the interior Columbia Basin indicate that in watersheds managed for natural resources extraction, the number of large pools has decreased substantially since the early 1900s, resulting in a significant decrease in habitat diversity [McIntosh et al. (1994) as cited in NMFS (2019)].

Since 2007, to address these issues and to mitigate impacts associated with the operation of the CRS, the Action Agencies in cooperation with private, local, state, tribal and federal entities have implemented a variety of tributary habitat restoration actions throughout the UCR region to benefit UCR steelhead. Those restoration actions are summarized in Table 3-31.

Table 3-31. Tributary habitat improvement metrics: UCR steelhead, 2007–2015 [Reproduced from NMFS (2019)]

Action Type ^a	Amount Completed
Acre-feet per year of water protected (by efficiency improvements and water purchase/lease projects)	39,908.6
Acres protected (by land purchases or conservation easements)	250.0
Acres treated (to improve riparian habitat, such as planting native vegetation or controlling noxious weeds)	1,435.0
Miles of enhanced or newly accessible habitat (by providing passage or removing barriers)	201.0
Miles of improved stream complexity (by adding wood or boulder structures or reconnecting existing habitat, such as side channels)	28.2
Miles protected (by land purchases or conservation easements)	11.2
Screens installed or addressed (for compliance with criteria or by elimination/consolidation of diversions)	82

^a Several of these categories (i.e., acres protected, acres treated, miles of enhanced stream complexity and miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

In the 2019 BiOp, NMFS (2019) said the following:

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have 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 ISAB (2015) pointed out that there is compelling evidence for strong density dependence at current abundance levels for anadromous salmonids and suggested that habitat capacity has been greatly diminished. The ISAB also suggests that changes in environmental conditions within habitats accessible to salmon and steelhead stemming from the effects of climate change, chemicals, and intensified land use appear to have further diminished habitat capacity. The ISAB (2015) found that density dependence was observed in all 20 interior CR steelhead populations during the 1980 to 2008 brood years.

The ISAB (2015) noted that studies of density dependence during the spawning and incubation stage are rare. In addition, other factors, besides density dependence, such as sedimentation, streamflow, water temperatures, and winter freezing conditions can be responsible for significant mortality during spawning and incubation. The ISAB (2015) concludes by stating that both the UCR and Snake River Basin steelhead DPSs show density-dependent interactions have a strong effect on recruitment of adults. And while few studies have examined the main cause of the observed density dependence (i.e., limitations in spawning vs. rearing habitat), in steelhead, they suggest that the effect is most likely related to interactions during rearing more so than during spawning stages, and that further study is necessary to confirm this.

Key recommendations from the ISAB (2015) included: (1) account for density effects when planning and evaluating habitat restoration actions; (2) establish biological spawning escapement objectives that account for density dependence; (3) balance hatchery supplementation with the Columbia Basin's capacity to support existing natural populations by considering density effects on the abundance and productivity of natural-origin salmon and steelhead; and (4) improve capabilities to evaluate density dependent growth, dispersal, and survival by addressing primary data gaps.

Freshwater Migration Corridor

The freshwater migration corridor for UCR steelhead extends from the spawning and rearing areas in the UCR subbasins downstream to the Columbia River plume. Migration corridors are considered essential to the conservation of UCR steelhead. Human activities that have affected habitat in subbasin tributary reaches have already been discussed and contribute to the quality and quantity of water downstream and within the migration corridor of the Columbia River. Tributary habitat actions already-implemented support all UCR steelhead and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, removing barriers to spawning and rearing habitat, and other actions targeted toward addressing limiting factors (NMFS 2019). No CRS projects exist in the freshwater tributary corridors, and UCR steelhead are not exposed to the effects of any CRS operations until they reach the mainstem Columbia River reservoir created by the first dam they encounter.

The quality of designated critical habitat within the Columbia River migration corridor is a function of the cumulative impacts of upstream actions, including impacts from development along the corridor, dam existence and operations, and management within the CRS that affects both juvenile and adult UCR steelhead. All these factors combine to affect critical habitat in the mainstem and influence the migration corridor. Habitat within the mainstem Columbia River has been substantially altered by a number of factors, including basin-wide water management, the existence and on-going operations of CRS projects, and other human-related activities that have degraded water quality and habitat (NMFS 2019). Within the 2019 BiOp, NMFS describes those factors affecting the behavior and survival of UCR steelhead through the CRS, and that information is incorporated here by reference (NMFS 2019). However, the following material briefly summarizes that information.

Mainstem dams and dam operations can affect stream temperature, streamflow, gas supersaturation levels, and river habitats. Both the Snake and Columbia Rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Because the temperature regime has been modified, resulting in warmer late summer/fall water temperatures, it potentially affects juvenile and adult salmonids as well as fish community structure. Warmer stream temperatures may influence predation rates on juvenile fish by predatory fish species. Juvenile fish may also be affected when water is spilled from hydroelectric facilities that increase gas supersaturation and may lead to gas bubble trauma in fish. All projects create impoundments that affect riverine habitats and can affect travel times, which in turn may increase juvenile fish exposure to both native and non-native predators. Some passage routes through dams may decrease juvenile fish survival (e.g., turbines) compared to spill bays and surface passage routes that are operated to increase overall juvenile passage survival. The processes, general effects, and mitigation of CRS mainstem dams and dam operations on the functioning of critical habitat are shown in Table 3-32.

Table 3-32. The processes and effects of the CRS dams and dam operations and mitigation efforts to address the effects

Process	Effect	Avoidance, Minimization, or Mitigation Measure
Passage at dams	Reduced juvenile survival due to the existence of the dams (baseline), recent improvements in survival since CRS overhaul	Surface passage, increased proportion of spill, flow augmentation, TDG management, bypasses, and fish-friendly turbines
Water storage operations	Altered water quantity and seasonal timing	Flow augmentation
Solar radiation/reduction in mainstem stream velocity	Altered temperature for late summer and fall fish migrants, both in the reaches below the large mainstem storage projects and migration corridors	The dams result in water temperatures that are slightly better (cooler) during the spring migration
Water storage	Reduced sediment transport and turbidity in migration corridors and estuary due to dam existence and to a lesser extent the ongoing operations of the CRS	Management for flow augmentation
Spill	Increased total dissolved gas	System-wide TDG management
Modification (impoundment and water level fluctuation) of mainstem migratory and rearing habitat	Altered food webs, including both predators and prey due to the existence of the dams and to a lesser extent the ongoing operations of the CRS	Avian management, fish bypass outfall placement (away from known predator concentrations), and pikeminnow removal (management)

In July–August, during the peak of the UCR steelhead adult migration, solar radiation heats water in the surface layer of reservoirs. This heating can lead to increased water temperatures and temperature differentials in the fish ladders in the CRS and other hydro projects. Stream temperatures within fish ladders exceeding 68°F and differentials greater than 1.8°F have been demonstrated to cause delay in steelhead and can reduce their successful migration to natal tributaries (Caudill et al. 2013). Stream temperatures within fish ladders commonly exceed 68°F and fish ladder differentials regularly exceed 1.8°F while UCR steelhead are migrating [McCann (2018) as cited in NMFS (2019)]. During the most extreme summer days, stream temperatures within fish ladders in CRS dams can exceed 75.0°F, and fish ladder temperature differentials can exceed 4.5°F [FPC (2019) as cited in NMFS (2019)]. There are currently no structures to reduce ladder temperatures at the mainstem Columbia River CRS dams, but research is ongoing to identify if cooler water is available and can be pumped into fish ladder exits.

Since 2008, as modifications to the physical and operational CRS system were implemented based on the 2008 BiOp, survival of UCR juvenile steelhead and adult migrants has improved substantially. As noted earlier, the average reach survival rate was 0.74 for juvenile hatchery UCR steelhead from McNary to Bonneville Dam.

For adult UCR steelhead, for the years of 2008 to 2017, the McNary to Priest Rapids Dam to the McNary to Wells Dam reach indicates that the average survival rate from 2008–17 was about 96.9 percent [100 – (76.5 – 73.4)] through the Priest Rapids Reservoir; Wanapum, Rock Island, and Rocky Reach Dams and reservoirs; and Wells Dam reaches. This estimate of minimum survival accounts for all sources of

mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 97.3 percent per project (NMFS 2019).

Estuarine and Nearshore Ocean Areas

Critical habitat has been designated for UCR steelhead in the Columbia River estuary (NMFS 2019). NMFS has defined the estuary to include the tidally-influenced portion of the Columbia River, i.e., from Bonneville Dam (RM 146) to the mouth of the Columbia River, including the lower portions of tributaries influenced by tidal action. As such, the lower 26 miles of the Willamette River are also included within the estuary domain.

NMFS (2019) considers a functioning estuary essential to the conservation of UCR steelhead. NMFS identified the PBFs for UCR steelhead in the estuary to include areas free of obstruction with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater 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.

NMFS (2019) identified degraded habitat conditions in the estuary as a limiting factor for UCR steelhead. Historically, the Columbia River estuary was more dynamic than it is today. Multiple channels, extensive wetlands, sandbars, and shallow areas, especially in the downstream 50 river miles, were influenced by winter and spring floods, low flows in late summer, large woody debris, and high sediment loads (NMFS 2019). As reported by NMFS (2019), the current conditions of the Columbia River estuary have changed as a result of many factors, including dredging to deepen and maintain the Federal Navigation Channel and the existence of jetties and pile-dike fields to stabilize and concentrate river flow. Causeways have been constructed across waterways. As noted by NMFS (2019), the mouth of the Columbia River was historically about 4 miles wide but has decreased to about 2 miles wide, and the depth has increased at the Columbia River channel at the bar from less than 20 feet to more than 55 feet.

In particular, NMFS (2019) reported a dramatic decrease in wetland areas in the Columbia River estuary. More than 50 percent of the marshes and spruce swamps have been converted to industrial, transportation, recreational, agricultural, or urban areas, with more than 3,000 acres converted since 1948 (NMFS 2019). In the upper reaches of the estuary, many wetlands on the floodplain have been converted to industrial and agricultural lands after levees and dikes were constructed. As reported by NMFS (2019), 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost since the late 1800s. Those wetlands support salmonid food webs both in shallow water and in the mainstem.

Changes in streamflow and sediment delivery have also affected critical habitat in the Columbia River estuary. NMFS reports that water storage and release patterns from reservoirs upstream have changed the seasonal pattern and volume of discharge within the Columbia River estuary (NMFS 2019). Discharge has increased in the winter and peak spring/summer floods have been reduced. NMFS (2019) also reported that model studies indicate that combined human activities in the Columbia Basin have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine-sediment transport by 50 percent or more. The significance of changes in sediment delivery to UCR steelhead is unclear, although

estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean, and subyearlings that may spend months in the estuary [Johnson et al. (2018); PNNL/NMFS (2018); and Weitkamp (2018) as cited in NMFS (2019)].

In terms of critical habitat, there are no CRS-related barriers to migration in the estuary, and there is no evidence that flows are insufficient for migration.

PROPOSED ACTION COMPONENTS SPECIFIC TO UCR STEELHEAD

The Proposed Action of continuing to operate and maintain the CRS and implement associated mitigation is fully described in Chapter 2 of this document and associated appendices. Reclamation is also consulting on the Columbia River mainstem effects of six irrigation projects that have additional and separate ESA reviews.¹⁴ The Proposed Action continues multiple operations that benefit UCR steelhead, including flow augmentation, spill, surface passage, intake screen bypasses, and adult ladder operations. In addition, mitigation activities that have been implemented as part of previous BiOps will continue, including tributary and estuary habitat improvements; fish, avian, and pinniped predator management; and hatcheries for conservation and safety-nets (see Chapter 2). The Action Agencies will continue to coordinate with regional sovereigns and will regularly update plans for water management, fish passage, fish operations, and water quality. The Action Agencies intend to implement these actions commencing in September 2020.

UCR steelhead are exposed to CRS management as follows:

- Streamflow quantity and quality in the Columbia River downstream of the Snake River confluence and out to the ocean;
- Passage through four CRS dams in both the downstream and upstream migrations.

EFFECTS OF THE ACTION ON UCR STEELHEAD DPS

The overall effects on UCR steelhead of continuing to operate and maintain the CRS involve lessening the negative effects of baseline passage impediments and advancing safe downstream and upstream passage through the CRS mainstem lower Columbia River dams. Effects of the Proposed Action would include, for example, any potential delayed/latent mortality hypothesized to occur as a result of how operating the dams affects juvenile salmon and steelhead passage at the dams; changes in juvenile fish travel time as a result of upriver operations; and potential exposure to elevated TDG as a result of voluntary spill. Improving juvenile and adult migration survival has been the focus of structural and operational actions under past BiOps, the benefits of which have been documented [Corps et al. (2017a); Bonneville et al. (2018a), Appendix D]. The already-completed structural actions are part of the

¹⁴ Columbia River mainstem effects of certain Reclamation irrigation projects are included in this CRS consultation because the Columbia River hydrologic modeling incorporates all such impacts. The mainstem Columbia River impacts are included for the Yakima, Umatilla, Deschutes, and Crooked River irrigation projects. Upper Columbia River steelhead do not spawn or rear in any of these tributaries. However, the flow impacts of these projects to the mainstem Columbia River are fully integrated in discussions of flow and TDG in the parts of the migratory corridor used by this DPS is impacted by these projects.

baseline condition and will continue to provide benefits in the future. The effects of the Proposed Action on the UCR steelhead DPS and its critical habitat are described by life-stage next.

Freshwater Spawning, Rearing, and Migration to the CRS

In their spawning and rearing areas, UCR steelhead are not exposed to the effects of operation of the Proposed Action because no operations (e.g., flood risk management, irrigation, power generation) occur in these areas. Because of this lack of exposure, there will be no direct effects from CRS management to individual fish in these areas.

Some individual fish of this DPS are exposed to habitat improvements through the Tributary Habitat Improvement Program component of the Proposed Action. UCR steelhead will benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that will result from the tributary habitat actions. Adverse effects to individuals from the construction of habitat improvement actions are mitigated through compliance with BiOps for the Tributary Habitat Improvement Program (NMFS 2013; USFWS 2013). Habitat improvements are proposed for the Wenatchee, Entiat, Methow, and Okanogan river watersheds, which make up the one major population group for this DPS. Activities in freshwater spawning, rearing, and migration habitats include work to improve streamflow protection and enhancement, habitat access, stream complexity, riparian habitat, screening to reduce entrainment, and more. These actions will continue to improve habitat condition over the baseline condition.

Juvenile UCR Steelhead Downstream Migration Through the CRS

Juvenile UCR steelhead are not exposed to the effects of CRS operations until they reach the mainstem Columbia River. After which, they migrate downstream through four to nine dams (five of which are owned and operated by PUDs), depending on their subbasin of origin. In this mainstem migration corridor, juvenile UCR steelhead will continue to experience the deleterious impacts of a degraded environmental baseline, including the existence of dams and associated cumulative effects.

Through previous actions, operations and structures at individual CRS mainstem dams have been modified and adapted for the specific conditions of each dam to reduce turbine passage, decrease forebay and tailrace residence times, and improve overall dam passage survival (Bonneville et al. 2017).

In general, the Proposed Action will continue operations and implement actions to minimize negative effects from both baseline conditions and the Proposed Action. Measures presently being implemented and proposed to continue include flow augmentation; measures to direct juveniles away from turbines, e.g., voluntary spill, surface passage structures and intake bypass systems; fish-friendly turbines; and predator management.

Changes included in the Proposed Action compared to past operations include a Flex-Spill operation and a new summer spill operation. Because juvenile UCR steelhead do not migrate during the summer, any changes in summer spill will not affect this DPS. Changes as a result of flex spill during spring are intended to increase juvenile passage survival for UCR steelhead passing downstream through the CRS and decrease any potential latent/delayed mortality.

The indicators (also termed factors) used below to assess the effects of the Proposed Action on juvenile UCR steelhead migration through the CRS are categorized as operational (modeling metrics, survival at

CRS dams, mainstem CR fish travel time, powerhouse passage proportion, TDG, temperature, turbidity, and predation) and non-operational (predation management, habitat actions, and fish status and trend monitoring). Using these indicators, analyses of effects to UCR steelhead during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Modeling results

The EIS COMPASS modeling results¹⁵ support the anticipated results of the qualitative analysis that found that juvenile UCR steelhead survival rates from McNary Dam to Bonneville Dam would increase from the Proposed Action compared to the current condition. The COMPASS model predicted that survival would increase less than one percentage point (Table 3-33). Travel time and powerhouse passage are predicted to remain close to the same as the current condition (Table 3-33). The COMPASS model suggests that the average exposure to TDG will increase for MO4 almost 4 percentage points, while TDG-related survival will increase with the Proposed Action (Table 3-33).

Table 3-33. Model metrics for juvenile UCR steelhead

Metric (Model)	NAA (2016 Ops)	MO1		MO4		Range
		Value	Change from NAA	Value	Change from NAA	
Juvenile Survival (COMPASS)	65.80%	65.60%	0.30%	66.10%	0.46%	0.50%
Juvenile Travel time (COMPASS)	6.6 days	6.7 days	1.52%	6.6 days	0	0.1 days
% Transported (COMPASS)	NA					
Powerhouse Passages (COMPASS)	2.72%	2.59%	4.78%	2.31%	-15.07%	0.41%
TDG Average Exposure (TDG Tool)	115.6% TDG	115.8% TDG	0.17%	119.8% TDG	3.63%	4.2% TDG
TDG-related Juvenile Survival	97.50%	97.40%	0.10%	93.90%	-3.69%	3.6.0%

Although life cycle abundance modeling was not available for UCR steelhead, insights from both the CSS and NWFSC LCMs can be considered in discussing abundance. The NWFSC LCM relies heavily on the date of arrival to estimate ocean survival and does not consider any increases or decreases in latent/delayed mortality. As noted above, based on COMPASS modeling, travel time and juvenile survival would be similar to NAA, meaning a similar number of juveniles would arrive at the ocean with timing similar to the current condition. One could expect the result would be adult abundance to also be similar to the current condition.

¹⁵ The CSS model was not employed for UCR species.

Considering CSS theory, Haeseker et al. (evaluated natural-origin steelhead populations from the Entiat and Methow using CSS SR steelhead relationships, based on the CSS finding that UCR steelhead populations have similar responses to fresh water migration conditions (powerhouse passage experiences, flow) and marine conditions as their Snake River counterparts (DeHart 2019). While that analysis did not model all the MO4 measures, spill to 125 percent TDG at the four lower Columbia projects was estimated to produce a 3.7 percent SAR for the Entiat/Methow steelhead (DeHart personal communication), producing a 28 percent increase relative to the baseline condition used by CSS modelers (Haeseker et al. ; DeHart 2019) that may be similar to the current condition. Presumably, this increase would be a result of decreased latent mortality in the ocean.

Survival at CRS Dams

Survival of UCR steelhead juveniles once they enter the Columbia River is influenced by a suite of factors—passage conditions at mainstem dams, flow conditions, water quality (e.g., temperature, TDG), predators, etc. Survival studies show, with few exceptions, that measures implemented through the previous CRS BiOps, and continued into the current Proposed Action, have performed as desired, achieving or very close to achieving the 2008 BiOp juvenile dam passage survival objective of 96 percent for juvenile steelhead (NMFS 2017e).

While turbine survival for juvenile migrants is generally lower than spillway survival, survival for surface passage and intake bypass routes can be close to, equal to, or even greater than spillway survival in terms of direct dam survival. The COMPASS model relies on juvenile route-specific survival estimates and predicts the Proposed Action's increase in spill (flexible spill up to 125 percent TDG) will result in an increase in juvenile UCR steelhead reach survival passing up to nine dams (four are CRS facilities). It is important to note that since higher spill levels result in unbalanced energy and 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; however, most predictions are for increased survival.

As noted earlier, average annual reach survival of hatchery-origin steelhead from the UCR (only hatchery-origin UCR steelhead have been used for survival calculations) from McNary Dam to Bonneville Dam (235 km) increased from 74 percent (2003–2007; no estimates for this reach in 2008) to 79 percent (2009–2018) (Widener et al. 2019). Implementation of the Proposed Action is expected to maintain or improve survival of UCR steelhead migrating through the system and reduce any potential latent/delayed mortality after they pass Bonneville Dam. The COMPASS model estimates that survival could increase juvenile survival from McNary Dam to Bonneville Dam by less than one percent higher than the 2016 operation.

Mainstem CR Fish Travel Time

Under the flex spill plan, spring operations at the eight mainstem CRS dams will include spilling to state water quality limits (anticipate 125 percent starting in 2020) for 16 hours per day and to performance spill operations for 8 hours per day. Patterns and amounts for the performance spill operation were developed using a combination of prescribed spill and performance standard testing guidelines from the 2008 FCRPS BiOp and gas cap spill that uses spill up to state water quality standards, with some restrictions for erosion concerns and powerhouse minimums. The main effects of increased spill

discharge will be a decrease in forebay delay and an increase in spill passage efficiency, with a reduction in hypothesized latent/delayed mortality (NMFS 2019).

Modeling estimates reveal that fish travel time from McNary Dam to Bonneville Dam will be slightly reduced. Additional flow through the spillways will likely draw a greater proportion of juvenile steelhead migrants from the powerhouse routes (turbines, intake screen bypasses, and sluiceways).

Implementation of the Proposed Action could decrease juvenile travel time by less than one percent. Decreasing juvenile travel time with higher levels of spill through the CRS can provide a survival advantage by reducing exposure time to predators and fostering a more normative synchrony between the physiological process of smolt transformation and the timing of ocean entry.

Under the Proposed Action, UCR steelhead would continue to not be transported as part of the juvenile fish transportation program.

Powerhouse Passage Proportion

In addition to the spill operations in the Proposed Action, the Action Agencies propose to modify the spillway surface passage weirs and install biologically-based designed turbines at John Day and McNary dams. These actions to improve baseline structural conditions are anticipated to increase survival of juvenile fish that pass through those routes. In addition, increasing the proportion of water discharged as spill directs a higher fraction of migrants away from powerhouses and toward spillways. This will reduce smolt encounters with turbines and intake screen bypass systems, both of which have been hypothesized to contribute to latent/delayed mortality. The COMPASS model predicts a potential slight decrease (< 1%) in powerhouse encounters for juvenile UCR steelhead as a result of these actions.

Total Dissolved Gas

Spill at CRS dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. This may occur during periods of high flows when involuntary spill is necessary or during set periods of time when water is spilled purposefully to implement the Proposed Action. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, which can result in injury or death. Survival of juvenile salmonids can decrease when TDG levels exceed lethal limits and fish are not able to compensate by swimming into deeper water (Beeman and Maule 2006).

Biological monitoring within the CRS shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 125 percent of saturation (Antcliffe et al. 2002; Backman et al. 2002; NMFS 2019). When those levels are exceeded, however, there is a corresponding increase in the incidence of signs of GBT symptoms. McGrath et al. (2006) determined that new research supports previous research indicating that short-term exposure to up to 120% TDG does not produce significant effects on juvenile (or adult) salmonids when compensating water depths are available (Beeman and Maule 2006; NMFS 2019). Therefore, it is anticipated that any increase in TDG as a result of implementing the flex spill operation will result in negligible increases in GBT to outmigrating juvenile UCR steelhead through the CRS because the Proposed Action is not intended to exceed the 125% “gas cap” during periods of voluntary spill.

Temperature

Temperature influences growth and feeding rates, metabolism, development, migration timing, and the availability of food. In addition, temperature plays a role in predator fish behavior which also affects juvenile salmonid survival. Adverse (high) water temperatures, however, can cause stress and mortality to UCR steelhead.

Current temperature conditions are different from historical conditions as a result of a suite of anthropogenic activities (see the status of the species section). Generally, though, water temperature is not sufficiently elevated to be detrimental to UCR steelhead when they are actively migrating downstream in spring through the CRS. During this time, the Proposed Action is not anticipated to change the current temperature regime in the Columbia River. Therefore, it is expected that temperature changes attributable to the Proposed Action are likely indistinguishable from current conditions and will result in negligible effect to outmigrating juvenile UCR steelhead.

Turbidity

The existence of the CRS (and non-federal dams) has decreased sediment transport downstream in the Columbia River Basin, as suspended particles tend to settle out when sediment-laden water enters a reservoir, thereby reducing turbidity. These conditions are part of the environmental baseline. Lowered turbidity levels may increase the susceptibility of UCR steelhead to avian and piscivorous predators due to increased visibility in the water column.

Implementing the Proposed Action is unlikely to result in changes in the amount of suspended sediment (and resulting turbidity) in the water column through the CRS. However, while outmigrating juvenile UCR steelhead will continue to experience a less turbid system as a result of past actions, the Proposed Action does include measures to address predation impacts in the vicinity of the dams and in the estuary, as described next.

Predation

A variety of bird and fish predators consume juvenile UCR steelhead on their migration from tributary rearing areas to the ocean (see Section 3.2.1.4). Existing conditions create habitat that is more ideal for both native and non-native predatory fish than pre-CRS conditions. Outmigrating juvenile UCR steelhead encounter predatory fish during passage through reservoirs, dam forebays, and dam tailraces of the CRS.

Juvenile steelhead survival is expected to increase by up to 5% through the John Day Reservoir during the spring migration period as a result of deterring Caspian tern nesting at Blalock Island Complex with increased reservoir elevations as defined by the proposed action (see Chapter 2) (Evans et al. 2019). Increased reservoir elevations are expected to decrease travel rates through the John Day reservoir. Decreased travel rates may increase vulnerability to predation by piscivorous fish.

Implementing operations of the Proposed Action will not substantially change environmental baseline conditions for the distribution and abundance of piscivorous fish in the CRS. Thus, while outmigrating UCR steelhead are anticipated to continue to be exposed to predation in the CRS, conditions under the Proposed Action are not anticipated to worsen. On one hand, fish in the dam tailraces that may be

particularly susceptible to predation could benefit from the flex spill program through increased spill discharge increasing turbulence immediately downstream of the dams, making it more difficult for predators to locate and prey upon juvenile salmonids in these areas. On the other hand, increased spill discharge may increase disorientation of outmigrants in spillway tailwaters, leading to increased vulnerability to avian predation.

Non-Operational

Predation Management

Management efforts to reduce predation by birds and northern pikeminnow will continue with the Proposed Action. Collectively, these efforts are intended to continue to minimize predation rates on outmigrating juvenile UCR steelhead passing through the CRS.

Bird predation is a significant environmental baseline source of mortality for UCR steelhead (Evans et al. 2018). The Action Agencies have developed various plans to help minimize predation by birds. In 2014, the IAPMP began (Corps 2014a). This plan manages avian predation on juvenile salmonids as they migrate to the ocean by reducing bird nesting colonies in inland areas by installing a variety of passive nest dissuasion materials prior to nesting seasons (Evans et al. 2018). A Double-crested cormorant management plan for East Sand Island in the estuary was completed in 2015. And, avian dissuasion actions at the dams (e.g., wires, sprinklers, etc.) will continue with the Proposed Action.

Prior to the IAPMP, tern predation on UCR steelhead averaged 16 percent from the colony located at Goose Island, which is on Potholes Reservoir. After management activities began in 2014, predation on UCR steelhead was reduced to 2.9 percent in 2014, and there have been no colonies nesting on Goose Island since 2015 (Collis et al. 2019). While the most significant tern predation of UCR steelhead historically has occurred from the Goose Island colony, other colonies have also impacted UCR steelhead. For example, Crescent Island, which is in the McNary Reservoir, has had similar results from the IAPMP, where prior to management activities, predation on UCR steelhead averaged 2.3 percent, and there have not been any colonies nesting there since 2014. Continued implementation of this plan in the Proposed Action will continue to minimize predation from birds on juvenile salmonids, including UCR steelhead.

The northern pikeminnow, a native fish, is a significant predator of juvenile salmonids in the Columbia River. In 1990, the Action Agencies began the NPMP to reduce predation on juvenile salmonids by northern pikeminnow through targeted removal of northern pikeminnow at mainstem CRS dams. In addition, a Pikeminnow Sport Reward Fishery program has been instituted that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake Rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. Incidental catch of ESA-listed salmon and steelhead as a result of implementing pikeminnow management programs has occurred in the past and is likely to continue at a similar rate in the future. While the numbers are low, some individuals are likely part of the UCR steelhead DPS.

Predator management programs will continue under the Proposed Action. They are anticipated to continue to maintain benefits achieved to date for reducing consumption of juvenile salmon and

steelhead by avian and fish predators. The proposed measure at John Day to inundate the Blalock islands to dissuade tern nesting would benefit spring migrating salmon and especially steelhead. Further, continuing to implement the Caspian tern and Cormorant management plans and the NPMP will result in negligible changes in predation, but will prevent the impacts from “backsliding” to levels that were occurring prior to the Action Agencies’ implementation of these plans.

Fish status and trend monitoring

There are potential effects from CRS-related RM&E programs on UCR steelhead associated with the capturing and handling of fish. RM&E activities occur throughout the Columbia River Basin as part of managing the CRS. In general, the RM&E program is a collaborative, regionally-coordinated effort for status and trend monitoring for habitat and fish, action effectiveness monitoring and research, critical uncertainty research, synthesis and evaluation, and data management. Capturing, handling, marking, tagging, and releasing fish is generally stressful and can have sublethal and sometimes lethal effects. Furthermore, some RM&E actions also involve euthanizing fish for research purposes. NMFS (2019) estimated the number of juvenile UCR steelhead that have been handled each year during the implementation of RM&E under the 2008 BiOp and determined that the average handling and mortality were not substantial. They concluded:

...slightly more than one percent of the wild juvenile production was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to one percent of these juveniles (in this case, <0.02 percent of the wild production) died after they were released due to effects of handling. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of FCRPS operations, including modifications to facilities, operations, and mitigation actions.

It is reasonable to assume that implementing the Proposed Action will result in the number of individual UCR steelhead handled, injured, and/or killed from RM&E activities continuing in the future at approximately the same level as is currently the case.

Juvenile UCR Steelhead Estuary Migration and Rearing, including the Plume

Ecosystems in the estuary (defined as Bonneville Dam to the ocean) and Columbia River plume provide habitat for juvenile UCR steelhead to migrate in, forage, adapt physiologically, and, in some cases, avoid predators. Most juvenile steelhead move through the estuary in 1 or 2 days, and survival in this reach appears to be high (Daly et al. 2014), excluding mortality associated with avian predation. The existence and operations of the CRS has led to long-standing changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, any direct impacts on these parameters due to the Proposed Action of continuing CRS management are expected to be minor.

There is an apparent relationship between plume characteristics at time of ocean entry and SARs for steelhead. Jacobson et al. (2012) found that steelhead SARs increased with the size and offshore distance of the plume under favorable large-scale ocean conditions, but did not change when ocean conditions were poor (Jacobson et al. 2012). It is not likely this relationship will be affected by the Proposed Action.

Avian predation continues to be a serious issue in the estuary, and juvenile steelhead appear to be targeted to a larger degree than other species (see Section 3.2.1.4). Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary as part of the Proposed Action will benefit this DPS by reducing the number of individuals of this DPS eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1].

The indicators used below to assess the effects of the Proposed Action on juvenile UCR steelhead migration through the estuary and plume are categorized as operational (survival, fish travel time, TDG, temperature, turbidity, and predation) and non-operational (predation management, habitat actions, and fish status and trend monitoring). Using these indicators, analyses of effects to UCR steelhead during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Survival

Foraging and growth in the estuary improves fish condition and likely increases subsequent survival during early ocean residence. Monitoring and research data suggest that fish size and time of ocean entry, which are in part due to conditions in the estuary, can affect salmonid growth and survival in the ocean (Chittaro et al. 2018; Johnson et al. 2018). Habitat enhancements that increase access to rearing areas, improve habitat capacity (e.g., prey productivity), and increase prey export to the mainstem estuary likely lead to increased growth and improved conditions of migrating juvenile UCR steelhead in the estuary.

Fish Travel Time

Changes in CRS water management in the Proposed Action are not expected to alter fish travel time through the estuary. Therefore, under the Proposed Action, travel time in the estuary of juvenile UCR steelhead is not likely to change from the baseline condition.

Total Dissolved Gas

Elevated TDG levels occur during periods of increased spill downstream are attenuated by approximately RM 110 in the estuary (NMFS 2019). Juvenile UCR steelhead exposed to increased TDG levels (120% to 125%) are likely to experience slight increases of GBT resulting from the Proposed Action as compared to the baseline condition.

Temperature

As mentioned above, during the time when juvenile UCR steelhead are outmigrating, the proposed operation of the CRS has limited capabilities to modify water temperatures in the mainstem Snake and Columbia Rivers. Therefore, water temperature changes due to the Proposed Action are not expected in the estuary.

Turbidity

Implementing the Proposed Action is not likely to affect turbidity levels in the estuary and plume.

Predation Rates

The Proposed Action is not anticipated to have any effect on the rate of predation of juvenile salmonids in the Columbia River estuary and plume.

Non-Operational

Predation Management

The Proposed Action will continue to implement the various predator management programs that are currently being implemented in the estuary and mainstem Columbia River. Some ESA-listed fish are captured as part of implementing the Pikeminnow Sport Reward Fishery and dam angling program. The number of individual fish impacted is likely to continue at a similar rate in the future. While the numbers are low across the entire program, some individuals below Bonneville Dam and in the estuary may be captured, injured, or killed.

Estuary Habitat Actions

As part of the Proposed Action, the Action Agencies will continue implementing the Columbia Estuary Ecosystem Restoration Program (CEERP) to improve estuary floodplain habitats, including tidally-influenced portions of tributaries, used by outmigrating salmon and steelhead. The planned improvements in habitat functions are expected to provide long-term benefits to native species that use these habitats through improved ecological functions and processes. Appropriate ESA consultation is typically undertaken prior to implementation of these projects at site-specific scale. These ESA consultations are complete with implementing Terms and Conditions that the Action Agencies comply with. Project effectiveness is expected to increase over time as the restoring habitats mature and new, more effective restoration projects are implemented because program sponsors will be taking into account lessons learned from previous projects within CEERP's adaptive management framework (Diefenderfer et al. 2016).

Fish Status and Trend Monitoring

The RM&E component of CEERP includes actions to monitor the status and trends of habitat and fish, perform action effectiveness monitoring and research, and conduct critical uncertainties research. CEERP is implemented using an adaptive management process to capture learning from RM&E and adjust accordingly program strategies and actions (Johnson et al. 2018). RM&E will continue under the Proposed Action. Capturing and handling of juvenile salmon and steelhead may result in stress, injury, or mortality as part of RM&E in the estuary and plume.

Ocean Rearing

CRS management has no *direct* influence on the survival of UCR steelhead in the Pacific Ocean. There are, however, a small number of individual salmon and steelhead that could experience deleterious direct effects from capture and handling from a Bonneville-funded study of juvenile salmonid ecology in the plume and nearshore ocean. *Indirect* effects on survival of UCR steelhead from CRS management include any latent/delayed mortality manifested in the ocean and the positive influence CRS management can have on juvenile migration and growth in the estuary, which is related to improved survival during early ocean entry.

The Proposed Action will have no effect on the ocean habitats used by UCR steelhead for growth and maturing because there are no CRS operations that affect this area (the Columbia River plume was addressed above).

Adult UCR Steelhead Migration to Bonneville Dam

Data on migration rates from the ocean to Bonneville Dam do not exist for UCR steelhead. However, NMFS (2014a) reported that adult SR spring/summer Chinook salmon took on average 18.1 days in 2011 and 15.4 days in 2012 to migrate up that reach of river. It is reasonable to assume adult UCR steelhead spend about 2–3 weeks migrating upstream in the estuary before reaching Bonneville Dam.

The Proposed Action is unlikely to cause adult migration barriers for UCR steelhead in the estuary where river discharge should be sufficient for adult migration. During periods of increased spill each spring, elevated TDG levels will likely extend about 35 miles downstream from Bonneville Dam (NMFS 2019). TDG, however, will attenuate due to the distance from CRS facilities combined with flows from tributaries below Bonneville Dam. As noted earlier, pinniped predation negatively affects adult migration within this reach, but this effect is not caused by CRS operations. The Action Agencies' proposed pinniped management actions at Bonneville Dam are expected to reduce this environmental baseline impact to some degree. Thus, overall, the Proposed Action is likely to have negligible effects on adult UCR steelhead in the Columbia River from the ocean to Bonneville Dam.

Further analysis of effects to adult UCR steelhead returning to the Columbia River and migrating up to Bonneville Dam as a result of implementing the Proposed Action is described next. The analysis is organized by operational and non-operational components.

Operational

Survival

The Proposed Action is not expected to negatively affect the migration corridor, and hence survival, for adult UCR steelhead in the estuary (Bonneville Dam to the ocean).

Travel Time

The Proposed Action will result in negligible reductions in flow and water particle velocity when adult UCR steelhead will be entering and migrating up the estuary (mostly during July and August). Therefore,

the Proposed Action is not expected to result in a measurable increase or decrease in the migration rate of adult UCR steelhead in the estuary.

Total Dissolved Gas

As a result of the flex spill operation during spring, early migrating adult UCR steelhead will be exposed to slightly elevated TDG levels. Most adult UCR steelhead, though, enter the Columbia River from the ocean in July and August after the flex spill program has concluded and, as such, will not be exposed to potentially elevated levels of TDG. Therefore, based on the attenuating effect on TDG of distance downstream of the CRS, the influence of tributary streamflow, and the timing of adult UCR steelhead migration to Bonneville Dam, the Proposed Action is not expected to adversely affect adult UCR steelhead in the estuary during migration to Bonneville Dam.

Temperature

Poor water quality, which includes increased water temperature, can lead to stress in adult UCR steelhead. This in turn can lead to reductions in biological reserves, altered physiological processes, increased disease susceptibility, and decreased performance of individual fish (e.g., growth). Furthermore, elevated water temperatures can affect salmonid distribution, behavior, migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult UCR steelhead (NMFS 2019).

Effects of the Proposed Action are not expected to result in elevated water temperatures downstream from Bonneville Dam and, therefore, are not likely to negatively impact adult UCR steelhead within this reach.

Turbidity

Existence of the CRS has decreased sediment loads transported downstream by the Columbia River. In fact, it is estimated that the total sediment discharge into the estuary and the Columbia River plume is approximately one-third of pre-hydrosystem levels (NMFS 2019).

Effects of the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam and, therefore, are not likely to negatively impact adult UCR steelhead within this reach.

Non-Operational

Predation Management

For adult UCR steelhead migrating upstream in the estuary to Bonneville Dam, the primary factor affecting survival is pinniped predation. The existence of Bonneville Dam, which is part of the environmental baseline, likely causes pinnipeds to congregate downstream from that project. However, if Bonneville Dam were not present, the pinnipeds would likely congregate at Cascade Falls or other upstream falls, much like they do at Willamette Falls.

In a study assessing pinniped predation on adult salmonids and other species, Tidwell et al. (2018), estimated a consumption rate of 1.54 percent for all adult steelhead collectively and concluded that the estimate is a reasonable rate of consumption on UCR steelhead. As noted in the 2019 BiOp, average

pinniped impacts to summer migrating adult UCR steelhead are likely relatively small because pinniped counts are generally lower in July and August when most UCR steelhead pass Bonneville Dam (NMFS 2019).

To reduce the baseline condition of pinniped predation on adult salmonids, management measures such as hazing, removal, and structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates) will continue under the Proposed Action. No components of the Proposed Action are expected to change from current conditions associated with pinniped predation and therefore will not affect adult UCR steelhead.

Adult UCR Steelhead Migration Through CRS Dams

Adult UCR steelhead use fish ladders to swim past four CRS dams on their way to spawning grounds. Fish returning to the Wenatchee River Basin must pass seven mainstem hydroelectric projects (the four lower Columbia River CRS projects and three PUD dams), while fish entering the Entiat River pass eight dams, and those migrating to the Methow and Okanogan river basins pass nine dams. An analysis of effects to adult UCR steelhead migrating upstream through the CRS as a result of implementing the Proposed Action follows. The analysis is organized by operational and non-operational components.

Operational

As discussed previously, the Proposed Action includes a flex spill program for spill at CRS projects to a level where the state water quality limit for TDG is met 16 hours per day and a performance spill component is implemented 8 hours per day. The flex spill program will occur April 3 through June 20 at the lower Snake River projects and April 10 through June 15 at the lower Columbia River projects.

The Proposed Action also includes modifying the Bonneville ladder serpentine weir to reduce delay within the fishway (this structural change is included under operational effects for convenience) and providing flexibility to decrease pool elevation in the John Day Reservoir by 0.5 feet to increase water particle velocity and reduce fish travel time. Collectively, these measures along with the flex spill Program have the potential to impact UCR steelhead, as described next.

Modeling Results

No life cycle modeling was completed for adult UCR steelhead. NWFSC LCMs for steelhead are still in development and not available for this analysis, and CSS LCMs modeling of alternatives were not provided for UCR species. However, insights from both the CSS and NWFSC LCM models can be considered in discussing abundance of returning adults.

The NWFSC LCM relies heavily on the date of arrival to estimate ocean survival and does not consider any increases or decreases in latent mortality. Based on COMPASS modeling, travel time and juvenile survival of UCR steelhead would be similar to current condition, meaning a similar number of juveniles would arrive at the ocean with timing similar to current condition. It is reasonable to assume that UCR steelhead adult abundance would also be similar to current condition.

Survival

Data on conversion and minimum survival rates were presented in the section above on factors affecting status of UCR steelhead.

Fallback

Adult UCR steelhead can fallback and pass downstream through CRS dams while migrating upstream to their natal streams. (Adult UCR steelhead also pass downstream as kelts.) Fallback through a dam after exiting into the forebay from a fish ladder is often associated with high spill levels at a project. As such, fallback tends to be higher for earlier migrants and kelts that encounter projects during the spill season, compared to later migrants that encounter projects after the spill season has concluded (Keefer et al. 2016). For adult UCR steelhead, mean annual fallback rates at lower Columbia River dams is about 6 to 9 percent (Keefer et al. 2016).

The Proposed Action, specifically the flex spill program, will have the potential to increase the rate of fallback at the four lower Columbia River CRS dams. With increased spill, it is likely more of the fish that fallback at a given project will do so through the spillway, or some surface-oriented passage route. However, spill at lower Columbia River dams will terminate on June 15. For fish that do fallback during the flex spill program, survival is expected to be relatively high. At Bonneville Dam, direct survival tests using rainbow trout as a surrogate revealed that for fish passing downstream of the dam via the B1 Ice/Trash sluiceway and the B2 corner collector, survival was greater than 98 percent (after 48 hours). At McNary, direct survival was estimated to be approximately 98 percent through the TSW. Conversely, direct survival through the McNary turbines was estimated to be approximately 91 percent (Keefer et al. 2016). For later migrating fish, i.e., those that ascend the CRS after termination of the flex spill program, the rate of fallback is not expected to change. In summary, the Proposed Action has the potential to negatively affect UCR steelhead by increasing fallback.

Total Dissolved Gas

Adult UCR steelhead migrate upstream past Bonneville Dam as early as May, although most migrants are observed from July through September (NMFS 2019). Because of the increased TDG levels associated with the flex spill program of the Proposed Action, earlier migrating adult UCR steelhead will likely be exposed to elevated TDG levels. The majority of UCR steelhead, however, will be migrating through the CRS after the flex spill program has concluded, and will therefore not be exposed to elevated TDG levels.

As described previously, GBT is not typically observed when TDG levels do not exceed 120 percent, and generally does not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Elevated TDG levels are only expected to be encountered below McNary Dam, and will be reduced as UCR steelhead adults continue upstream over McNary and past the confluence with the Snake River. Therefore, based on the limited observations of GBT at expected TDG levels associated with the Proposed Action, and given the timing of adult UCR steelhead within the CRS, the Proposed Action is not expected to result in an elevated risk of GBT to UCR steelhead.

Temperature

As described previously, poor water quality, including increased water temperature, can have adverse effects on adult UCR steelhead. However, because actions associated with the Proposed Action are not anticipated to elevate water temperatures within the CRS, effects of the Proposed Action are not expected to affect adult UCR steelhead within this reach.

Turbidity

Hydropower development in the Pacific Northwest has altered the extent of sediment transport downstream through the Columbia River, including within the CRS. While other anthropogenic activities such as agriculture, irrigation, mining, logging, road building, etc. have increased sediment delivery to the mainstem Columbia River, both federal and non-federal projects act as sediment traps, decreasing sediment loads discharging downstream. These activities and baseline conditions are expected to continue at current rates.

Because actions associated with the Proposed Action are not expected to result in changes in baseline sediment load, the Proposed Action is not expected to affect adult UCR steelhead within the CRS.

Non-Operational

Predation Management

Predation on adult UCR steelhead within the CRS is rare. Pinnipeds are the primary predator of adult salmon and steelhead, and while pinniped predation commonly occurs in the Bonneville Dam tailrace and in the estuary downstream to the Pacific Ocean, pinniped observations upstream from Bonneville Dam are not common; no pinnipeds have been observed above The Dalles Dam. The Proposed Action is not expected to change pinniped predation on adult UCR steelhead in the CRS.

In addition, predator fish management programs, like the NPMP, could potentially effect UCR steelhead by the accidental hooking of adults at the dams and during fishing for northern pikeminnow elsewhere in the CRS. There is also potential for by-catch while the number of pikeminnow are being indexed through electroshocking. However, the incidental catch of adult UCR steelhead during these activities has remained below take limits for the NPMP (Williams et al. 2019).

Adult UCR Steelhead Migration Upstream of the CRS to Spawning Areas

After migrating upstream through the CRS, adult UCR steelhead begin to migrate to their natal streams. Along the way, they must pass a number of non-federal dams. Overall, the Proposed Action is not expected to adversely affect UCR steelhead as they migrate upstream of the mainstem CRS dams to their natal streams.

Operational

For the most part, exposures of UCR steelhead to the majority of CRS-related water quality and quantity aspects of the Proposed Action are reduced dramatically after passing the Snake River confluence and

moving up the Columbia River, although some influence from upper mainstem dams and other upriver CRS storage projects is still occurring. Once they enter their natal tributaries, adult UCR steelhead are no longer exposed to the operation and related effects of the CRS.

Non-operational

Within UCR steelhead tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this DPS. The following provides a description of the effects of those actions.

Hatchery Programs

The hatchery program described above will be implemented into the future without alteration under the Proposed Action. As such, no change in UCR steelhead is anticipated due to hatchery operations.

Tributary Habitat Actions

Nearly all of the historical habitat for UCR steelhead has been extensively modified through anthropogenic actions. As described previously, many factors limit the viability of this DPS. In response, many habitat measures have been implemented specifically to benefit UCR steelhead by federal, state, local, and private entities, including the Action Agencies.

Based on the best available science, NMFS has concluded that these actions have improved and will continue to improve habitat for UCR steelhead. Furthermore, fish population abundance, productivity, spatial structure, and diversity should respond positively to improvements to the baseline conditions (NMFS 2019).

Fish Status and Trend Monitoring

The Action Agencies' RM&E program is expected to continue at its current or a lesser level of effort. RM&E effects on UCR steelhead are associated primarily with the capture, handling, marking, and tagging of fish. The level of injury and mortality to adult UCR steelhead from RM&E is expected to be maintained at current or slightly decreased levels.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Effects of the Proposed Action on critical habitat for UCR steelhead were assessed based on the action's elements likely to affect physical and biological features (PBFs) essential for the conservation of the DPS. Effects cover critical habitat for tributary spawning and rearing, the freshwater migration corridor through the mainstem CRS dams, and the estuary and nearshore ocean.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of UCR steelhead. These areas occur upstream of the CRS so the effects of the Proposed Action are limited to tributary habitat mitigation actions intended to improve habitat function for UCR steelhead. For the Tributary Habitat Improvement Program, there will be some uncertainty about the actual locations,

extent, and types of tributary habitat actions that will be implemented as part of the Proposed Action. However, anticipated effects of the program are expected to be short-term and will be mitigated through compliance with the BiOp on Columbia River habitat improvements (NMFS 2013). Effects to critical habitat within the upper Columbia DPS from the Winthrop steelhead NFH and upper Columbia kelt reconditioning program are considered minor because hatchery effluents and fish health are expected to be compliant with current discharge permits and fish health policies and water quality plans (USFWS 2018). The operation and maintenance of these programs have undergone separate, program-specific ESA consultation with (NMFS 2019) and are part of the existing baseline conditions.

Freshwater Migration Corridors

Freshwater migration corridors are used by returning adult UCR steelhead migrating upstream through the CRS and by juvenile steelhead migrating downstream past Bonneville Dam. For UCR steelhead, the four lower CRS projects have affected and will continue to affect the function of critical habitat. Said habitat influences passage and survival of juvenile and adult migrants and is part of the environmental baseline. The Proposed Action includes ongoing actions to maintain or improve the freshwater migratory PBFs through operation and maintenance of passage improvements through the system and implementation of the predator management programs, which is intended to reduce the consumption of juvenile and adult salmon within the CRS. These programs are intended to improve downstream survival and will continue to reduce the risk of predation on UCR steelhead.

The Proposed Action also includes both structural and operational modifications to the CRS that may affect water quality and passage PBFs that UCR steelhead must migrate through to complete their life cycle. However, the overall effects to these PBFs from implementing the Proposed Action are slightly positive with respect to passage conditions and risk of predation, and slightly negative relative to elevated TDG. Continued effects to stream temperature, sediment, and turbidity are anticipated with CRS management, but effects to these water quality PBF indicators are likely to remain unchanged as a result of the Proposed Action. Passage conditions at each of the projects are anticipated to improve for juvenile steelhead as the flex spill program will provide more advantageous passage routes through spill bays at each of the projects. Increasing the proportion of water discharged through the spill bay surface weirs at each of the dams will reduce forebay residence time by providing a more pronounced surface-oriented flow path for juvenile steelhead, which decreases forebay residence time, improves dam passage survival, and is hypothesized to reduce latent/delayed mortality.

Estuary and Nearshore Ocean Areas

Estuary and nearshore ocean areas have been designated as essential for the conservation of UCR steelhead. Ongoing implementation of the CEERP and predator removal and harassment programs is anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of the CEERP is likely to increase the capacity and quality of habitat in the estuary while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal and harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to improve the safe passage feature of critical habitat.

The Proposed Action includes operational modifications to the CRS that may affect water quality habitat features downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions with a slight but potential increase in TDG associated with the flex spill program. The highest TDG levels (125%) are expected in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). Continued effects to the PBFs associated with stream temperature, sediment, and turbidity are anticipated downstream from the CRS but are likely to remain unchanged as a result of the Proposed Action. Current passage habitat features will be unaffected for juvenile and adult UCR steelhead as they migrate through the Columbia River estuary and into nearshore ocean.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on UCR steelhead in the context of environmental baseline and cumulative effects. Cumulative effects are effects of future state or private activities that are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline condition (whether they are federal, state, or private). To the extent those same activities are reasonably certain to occur in the future (and are state or private), their future effects are included in the cumulative effects analysis.

Most of the action, baseline, and cumulative effects identified in the analysis above are consistent with effects previously described for operation of the CRS in past consultations. In general, the Proposed Action as a whole is not likely to limit species survival or critical habitat function. It carries forward a suite of beneficial actions that improve baseline conditions and offset negative effects attributable to the regulation of flows, including flow augmentation, fish passage operations, predation management, and habitat improvement. Though the Proposed Action does not cause substantial changes to current species conditions, there may be some modest site-specific effects from the continued operation of the CRS. It is also possible that increased spill levels, and associated adverse effects, will be offset by an increase in adult returns due to less powerhouse encounters as hypothesized by the CSS.

The summary below follows the general structure of the effects analysis above, having operational and non-operational components.

Operational

Survival

Baseline survival of juvenile UCR steelhead through the CRS is affected by the number of dams they pass, predators, travel time, and water quality. These factors are the result of multiple influences, including the existence and continued operation of the CRS. Survival has improved for juvenile UCR steelhead migrating through the CRS to the ocean as a result of past actions. Juvenile steelhead survival has also improved in the estuary and tributaries due to habitat improvements implemented by the Action Agencies. For adult UCR steelhead, survival has been affected in the estuary up to Bonneville

Dam by pinniped predators, though less so than other salmon and steelhead runs. Survival of adults that overshoot their natal tributaries and must pass downstream of dams to get back to their natal tributaries is an on-going issue.

Cumulative future non-federal actions, and the effects of climate change and variable ocean conditions, have the potential to affect survival of UCR steelhead. Land use activities (primarily non-federal) have the potential to affect juvenile survival by decreasing tributary and estuary habitat or degrading abiotic factors, such as stream temperatures from urban, rural, and agricultural development and runoff. Further degradation of tributary habitat could also affect adult UCR steelhead survival by reducing holding and spawning areas, or development of passage barriers. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies implement fisheries that can have a direct effect on the number of returning steelhead to the UCR tributaries (and in some cases, within the tributaries themselves).

It is anticipated that survival gains resulting from previous actions will continue and possibly increase as a result of continuing tributary and estuary habitat actions. It is also anticipated that improvements to juvenile and adult passage conditions at the CRS dams will be maintained. For downstream migrating juveniles, it is anticipated that not only will survival through the CRS improve, but ocean survival may increase as a result of fish entering the ocean with fewer powerhouse encounters during their downstream migration, should the latent mortality hypothesis be valid. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications to actions.

Fish Travel Time

The development and operation of the CRS has slowed juvenile travel time compared to the pre-CRS condition, potentially increasing exposure to predators as they migrate through the CRS. Travel time within the tributaries and estuary are not affected by the existence or operation of the CRS. While travel time of UCR juveniles within the CRS varies from year to year, actions from the past that are on-going carry more fish through non-turbine routes, which is believed to decrease travel time and improve survival. Adult travel time is not considered an issue. However, increased water temperatures may lead to migrational delays at fishways or result in natal tributary overshoot; both of which may reduce spawning success.

Future non-federal actions are not expected to affect travel time of juveniles or adults through the CRS during any life stage. However, it is anticipated that projected increased air temperature due to climate change will continue to increase overall temperatures in the Columbia River, and therefore have the potential to further affect adult UCR upstream migrational timing, and possibly juvenile emigration timing.

The Proposed Action is anticipated to reduce forebay resident time (a decrease in downstream time) for juvenile UCR migrating past CRS during the flexible spill plan implementation. Continued monitoring of adult UCR steelhead migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse Passage Proportion

Past and current physical modifications and operations of the CRS have increased the percentage of juvenile fish passing non-turbine routes. Decreasing powerhouse passage improves the survival of juveniles during their downstream migration and earlier migrating adults that may fallback and have to migrate upstream past a dam again (by falling back through spill rather than the powerhouse).

The effects from state and private actions are not anticipated to affect juvenile UCR steelhead powerhouse passage.

The Proposed Action will continue implementing past improvements and actions that have resulted in increased non-turbine passage at the CRS projects. In addition, the Proposed Action will increase spill during the juvenile migration period and that is expected to result in fewer powerhouse encounters for juvenile UCR steelhead during their downstream migration.

Water Quality

Total Dissolved Gas

Total dissolved gas has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high rates that resulted in GBT in juveniles and adults as they migrated through the CRS. Elevated TDG levels are not observed within tributaries or the estuary (where the effects of CRS operations on TDG are attenuated by distance and tributary inflow). The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

It is anticipated that implementing the flex spill program will elevate TDG levels and may slightly increase the incidence of GBT in juvenile fish.

Temperature

Water temperatures have been modified as a result of a range of anthropogenic activities, including the existence and on-going operation of the CRS, throughout the Columbia Basin. Increases in temperature can have a range of effects on both juvenile and adult UCR steelhead.

Ongoing non-federal land management activities that affect temperature, such as agriculture and urban and rural development and forestry, are not expected to change substantially during the period of this consultation. These activities, coupled with continued population growth in the region, will likely result in further degradations to the environment that influence water temperatures. However, improvements may be realized from tributary actions that restore and preserve habitat, like riparian plantings.

Implementation of the habitat enhancement action component of the Proposed Action will continue to improve tributary temperatures but will continue to have minimal effect on mainstem temperatures.

Turbidity

Currently, sediment loads in tributaries have been affected by historic land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and

rearing habitat. In the mainstem Columbia River, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk.

In the tributaries, non-federal actions such as urban, rural, and agricultural development are likely to continue to affect turbidity; however, improvements in tributary habitat included in the Proposed Action are expected to result in reduced sediment inputs, resulting in modest, site specific improvements that will mitigate continued non-CRS activities that degrade habitat. In the mainstem Columbia River, the current condition is not anticipated to change, and no non-federal activities are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment delivery levels from the tributaries. On the mainstem Columbia River, it is not anticipated that the Proposed Action will change the current condition.

Dam Passage (adults)

Currently, UCR steelhead migrate upstream through one to four lower CRS projects on their way to natal spawning areas and experience a variety of factors affecting them, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish. Current adult passage conditions should continue with a slight modification of the upper serpentine flow control ladder section at Bonneville Dam, which should help reduce delay and improve fish passage. UCR steelhead appear to survive their migration through the CRS at high levels and those survival rates are expected to continue with implementation of the Proposed Action. In addition, steelhead that survive spawning and try to return to the ocean (kelts) can be affected by the CRS. Kelts should benefit from the flex spill program because surface-oriented passage routes through the spillways should guide more juveniles and adults (i.e., kelts) away from powerhouse passage routes.

Non-federal actions that have the potential to directly affect UCR steelhead adults migrating through the CRS are unlikely. However, the continued degradation of tributary habitat that increases temperatures and projected increased air temperatures due to climate change that is likely to result in warming surface water temperatures indirectly influence migratory behavior in ways that slow or delay upstream migration and reduce survival and reproduction.

The Proposed Action will continue to monitor adult migration through the CRS and use that information to propose specific actions that will increase adult survival.

Non-operational

Predation Management

Currently, both juvenile and adult UCR steelhead encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinnipeds prey on adults as they enter the Columbia River from the ocean to the tailrace of Bonneville Dam, often leading to the mortality of a portion of returning adult UCR steelhead. A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS, mostly in the tailraces of dams. This predation accounts for a portion of juvenile mortality during migration through the CRS.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS operation has no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

The Proposed Action will continue to implement the predator management programs to limit UCR steelhead mortality from environmental baseline conditions. This should ensure that predation caused mortality does not increase and may reduce overall predation rates. Some impacts to UCR steelhead will occur as a result of implementing the northern pikeminnow predation program, but is considered minor.

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to the operation of hydro facilities, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin salmon and steelhead and their habitat depends on the design of hatchery programs, the condition of the habitat, and the status of the species, among other factors.

The majority of hatchery programs are run by the state in which they occur. It is anticipated that most of the current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue. The potential deleterious effects of hatchery-origin fish on natural-origin fish will continue to be studied and management agencies will make recommendations to reduce those potential effects.

Habitat Actions

Habitat conditions in the tributaries, mainstem Columbia River, and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect UCR steelhead include the continued degradation of tributary habitat that increase temperatures and projected increased air temperatures due to climate change that is likely warming surface water temperatures and altering runoff patterns.

The Proposed Action will continue to improve the degraded baseline condition of habitat in the tributaries and estuary and thereby improve long-term survival of UCR steelhead.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on UCR steelhead. These are associated with the capturing and handling of fish. Research, monitoring, and evaluation activities occur throughout the Columbia River Basin as part of managing the CRS.

The proposed Action will continue to implement the RM&E programs that are currently occurring, with the potential to modify these programs in the future as the results of the monitoring programs are evaluated. While some individuals are harmed, even killed, as a result of RM&E activities, the actual numbers are relatively small, and the information gained outweighs these minor losses.

Summary

In Table 3-34, the Proposed Action is compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action.

Most of the actions are anticipated to either have no effect, or a positive effect compared to the baseline condition (Table 3-34). This is partly because the Proposed Action continues numerous beneficial actions developed over the preceding decade, including habitat improvement, flow augmentation, and fish passage operations. Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-34. Summary comparison of the Proposed Action to current conditions for UCR steelhead by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Fish status and trend monitoring	x	x	=	
Juvenile Steelhead Downstream Migration from natal stream through the CRS (Bonneville Dam)	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival.
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x	x	+	Continuation of predator management programs should decrease predation.
	Hatcheries	x	x	=	
	Predation monitoring	x	x	=	
	Fish status and trend monitoring	x	x	=	
Juvenile Steelhead Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Steelhead Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Steelhead Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce overshoot.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
Adult Steelhead Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring		x	=	

3.1.3.2 UCR Spring Chinook ESU

This section examines the status of the UCR spring-run Chinook salmon ESU, factors that have affected it, and the effects of the Proposed Action on it.

STATUS OF THE UPPER COLUMBIA RIVER SPRING-RUN CHINOOK SALMON ESU

UCR spring-run Chinook salmon (*O. tshawytscha*) were listed as endangered on March 24, 1999 (64 FR 14307). Status as endangered was reaffirmed in 2005, 2012, and 2016 (Good et al. 2005; Ford 2011; NWFSC (Northwest Fisheries Science Center) 2015; NMFS 2016b). This ESU occupies the Columbia River and its tributaries between Rock Island Dam and Chief Joseph Dam. Critical habitat for the ESU was designated on September 2, 2005 (70 FR 52630). The recovery plan was completed in 2007 (UCSRB 2007).

The extant UCR spring-run Chinook salmon ESU is composed of a single major population group (MPG) with three populations (Figure 3-20)—the North Cascades MPG with Wenatchee River, Methow River, and Entiat River populations. UCR spring-run Chinook were extirpated from the Okanogan River subbasin in the 1930s, but an active recovery program using Methow River composite stock has been initiated (NMFS 2019). Historically, UCR spring-run Chinook salmon populations likely also included two MPGs that were eliminated when construction of Grand Coulee and Chief Joseph dams blocked access to upstream habitat (UCSRB 2007; NWFSC (Northwest Fisheries Science Center) 2015). The production from six hatchery programs (Twisp River, Chewuch River, Methow River, Winthrop National Fish Hatchery, Chiwawa River, and Nason Creek) occurs within the North Cascades MPG. At one time, the White River hatchery program was included in the ESU, but it has been discontinued. All three

populations of the North Cascades MPG spawn upstream of dams on the middle Columbia River owned and operated by PUDs. These PUD dams are not included in the CRS Proposed Action. Their operation and maintenance has undergone separate Section 7 consultation and, as a result, the effects of those actions are not included in the Proposed Action for the CRS BA.

The status of UCR spring-run Chinook salmon ESU is regularly reviewed by NMFS for population viability (Good et al. 2005; Ford 2011; NWFSC (Northwest Fisheries Science Center) 2015). There are four basic parameters used to evaluate population viability status: abundance, productivity, population spatial structure, and diversity 2019. The most recent status review completed by NMFS in 2015 showed an increase in geometric mean abundance for natural-origin spawners over the 10-year period assessed (2005 to 2014). However, abundance for each of the populations remains below the minimum ICTRT threshold for recovery. Population productivity has increased for two of the populations and one has remained unchanged during this time period. The integrated spatial structure and diversity risk were considered high for all three of the populations of UCR spring-run Chinook salmon. The risk for natural processes was considered low for the Wenatchee and Methow River populations and moderate for the Entiat River population. The high-risk rating for diversity was primarily driven by the high proportions of hatchery-origin spawners in natural spawning areas and lack of genetic diversity among the natural-origin spawners (NWFSC (Northwest Fisheries Science Center) 2015). Best available information indicates that the status of UCR spring-run Chinook ESU was improving prior to declines in ocean conditions in recent years.

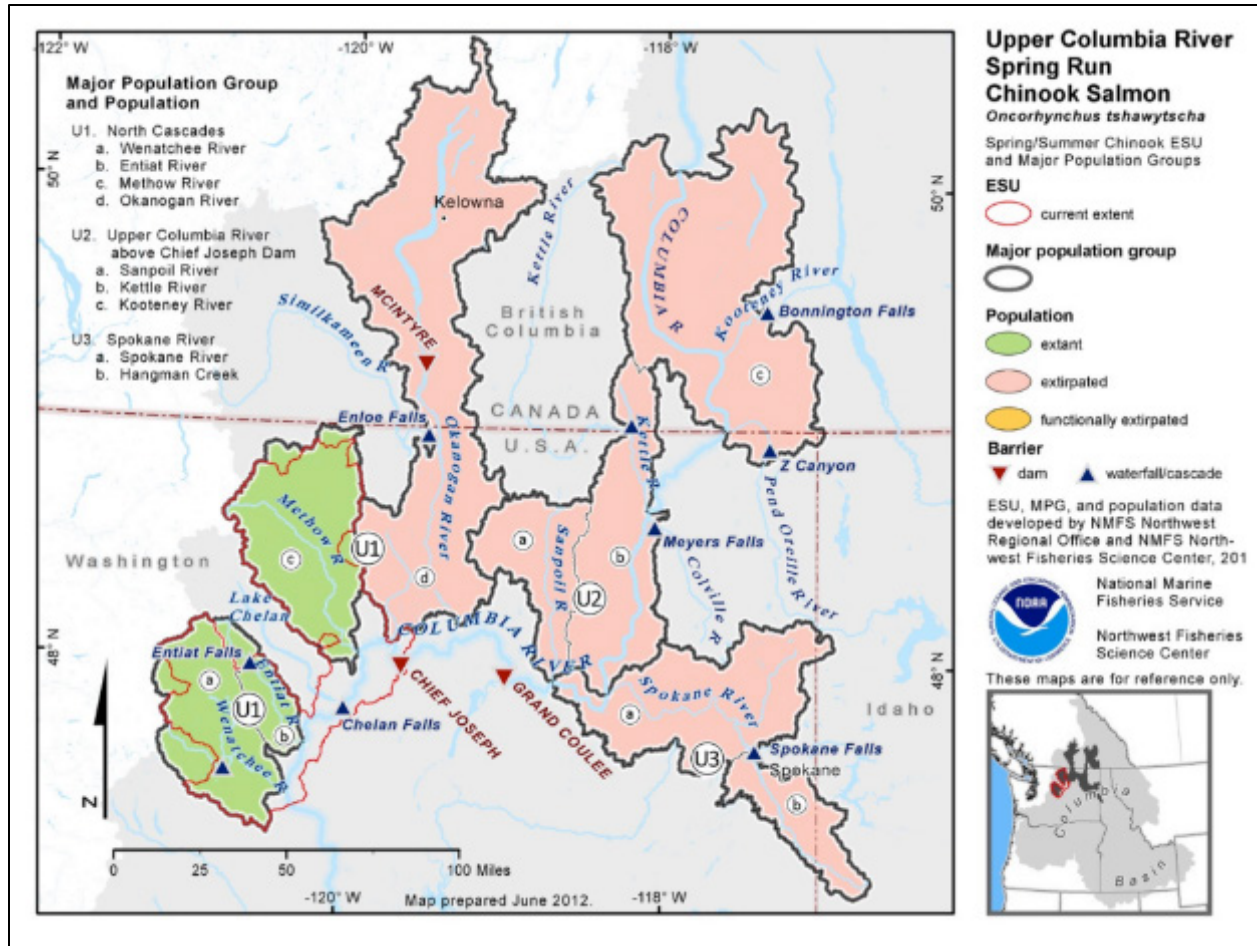


Figure 3-20. Map of the UCR spring-run Chinook Salmon ESU

FACTORS AFFECTING THE STATUS OF UCR SPRING-RUN CHINOOK

Within the UCR tributaries that support the spawning and rearing of UCR spring-run Chinook salmon populations, a variety of limiting factors affect both the species and their habitats. Processes such as climate change have contributed to altered water quality and quantity. Anthropogenic activities, including the trapping of beaver, mining, agriculture, livestock grazing, water diversions, and timber harvest have modified on a broad-scale the habitat UCR Chinook evolved to inhabit. Impacts associated with those activities include reduced water quality and quantity, decreased riparian function, reduced connectivity with side-channels and floodplains, and reduced habitat diversity (NMFS 2016b), resulting in reduced abundance and distribution of UCR spring-run Chinook salmon. Additional impacts from historic hatchery practices, harvest, predation, competition, and negative interactions with non-native fish species, impacts associated with dam passage, and degraded estuary and ocean conditions (NMFS 2019) also contributed to substantial reductions in the distribution and abundance of UCR spring-run Chinook salmon.

With a decline in salmonid production, and as a result a decline in spawners within natal streams, nutrients vital to juvenile production have also decreased dramatically. Gresh et al. (2000) estimated that since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only

about 6 to 7 percent of historical levels. They attributed this decline to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. These nutrients are important for salmonid production, and consequently for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2002).

Over a total life cycle, the greatest incidence of mortality occurs where UCR spring-run Chinook salmon spend most of their life, i.e., tributary and early ocean environments (see Section 3.2.1.1, Figure 3-1). Within tributary habitat, egg-to-emigrant mortality from all sources for UCR spring-run Chinook averages 96 percent (UCSRB 2014). Ocean mortality, which is highly variable, is typically greater than 95 percent, with mortality during the first year of residence being much greater than subsequent years. The UCSRB (Upper Columbia Salmon Recovery Board) compiled data for the years 1999 to 2017 and estimated mortality to be 35.5 percent for juvenile yearling Chinook migrating downstream from Rock Island to McNary Dam and 27.6 percent from McNary to Bonneville Dam (UCSRB 2019). In a similar evaluation, Widener et al. (2018) estimated mortality rates of UCR hatchery yearling Chinook salmon for the years 1999 to 2017 and estimated mortality rates from McNary to Bonneville Dam to average 18.2 percent. However, the foregoing may be an underestimate of mortality to Bonneville Dam. Buchanan et al. (2015) estimated that cohort mortality for the Chiwawa River (i.e., Wenatchee population) from natal tributaries to McNary Dam to be 88 percent, indicating that a significant portion of these fish perished before reaching the CRS. Other estimates using yearling migrants often miss the crucial first winter in natal streams. In the following material, factors affecting the status of UCR spring-run Chinook salmon by life-stage are presented.

Freshwater Spawning, Rearing, and Migration to the CRS

UCR spring-run Chinook use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. While much of the habitat modification are relics of past anthropogenic practices, NMFS (2019) identified several limiting habitat factors in these areas that continue to influence the species survival, including degradation of floodplain connectivity and function, reduced channel structure and complexity, degraded riparian areas and reduced large woody debris recruitment, reduced instream flow and water quality, and hatchery related effects.

The consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. The ISAB (2015) provided evidence for strong density dependence at current abundance levels for anadromous salmon and spring-run Chinook salmon and suggested that habitat capacity has been greatly diminished. Density dependence was observed in most rivers where data have been examined, despite natural spawners being much less abundant currently relative to historical abundance (ISAB 2015).

In an assessment of density dependence using a two-stage Gompertz model, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages. They found that due to density dependence during the parr-to-adult stage, a greater number of fish reaching the ocean may not substantially increase the number of adults reaching the spawning grounds. Based on this evidence, the authors concluded:

This suggests that life cycle modeling to date has been overly optimistic about the benefits of survival rate increases in the hydrosystem and elsewhere to improve the viability of salmon populations threatened with high extinction risk.

While the modeling framework of Hinrichsen and Paulsen (2019) was applied to SR spring/summer Chinook, the results are consistent with the 2015 ISAB report on density dependence. Therefore, it is reasonable to assume that UCR Chinook salmon are also experiencing similar effects of density dependence. The consequences of long-term habitat degradation are likely reducing overall habitat capacity for the species. ISAB (2015) has provided compelling evidence for strong density dependence at current abundance levels for anadromous salmon and suggests that habitat capacity has been greatly diminished (see Section 3.2.1.2).

Past and present effects of the existence of CRS dams and operations: UCR spring-run Chinook are not exposed to CRS facilities or operations during adult holding, spawning, egg incubation, and juvenile rearing and migration within the tributary environment. Adult mortality associated with the dams reduces marine derived nutrient levels in tributaries where they would have otherwise spawned and died.

Past and present effects of hatcheries: Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They can also help preserve genetic resources until factors limiting natural productivity 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.

Maier (2017) identified multiple factors that influence the ecological interactions of hatchery- and natural-origin fish. As noted by Maier (2017), those factors include the duration of cohabitation, relative body size, prior residence, location, and species differences, all of which influence competitive interaction. However, fish density relative to habitat carrying capacity likely exerts the greatest influence (Maier 2017). Maier (2017) also surmised that disease and predation can also be ecological interaction factors. The density dependence the ISAB (2015) documented (20 of 20 populations of interior CR spring/summer Chinook salmon studied) could partly have been a function of ongoing hatchery production.

NMFS has summarized the effects of hatcheries on UCR spring-run Chinook (NMFS 2019). The proportions of natural-origin contributions to spawning in the Wenatchee and Methow River populations have trended downward since 1990. In comparison, since the Entiat River National Fish Hatchery program was discontinued in 2007, there has been an upward trend in natural-origin fish. In the most recent status review, NMFS (2016b) concluded that the extent to which hatchery effects continue to present risks to the persistence of the ESU remains unchanged.

As noted earlier, the UCR spring-run Chinook ESU consists of three populations located in the Wenatchee, Entiat, and Methow River Basins. Juvenile Chinook salmon originating in the Methow River must migrate downstream through five mainstem non-federal Columbia River dams prior to encountering the CRS dams. Those five projects are owned and operated by the three mid-Columbia River PUDs—Douglas PUD (Wells Dam), Chelan PUD (Rocky Reach and Rock Island Dams), and Grant PUD (Wanapum and Priest Rapids Dams). Juveniles originating in the Entiat Basin experience one less

dam during their downstream migration (excludes Wells Dam), and Wenatchee UCR spring-run Chinook migrate downstream through two less dams (excludes Wells and Rocky Reach Dams). The mid-Columbia River PUDs consulted separately with NMFS through habitat conservation plans (HCP) for Douglas and Chelan PUDs, and a settlement agreement for Grant PUD. The Federal Energy Regulatory Commission (FERC) was part of the process and the HCPs were formally included into the PUDs’ FERC license after they were completed. The HCP and settlement agreement processes allowed NMFS to issue incidental take permits to address the effects of the operation and maintenance of their facilities on ESA-listed (and non-listed) species, including UCR Chinook salmon. All of these consultations were completed with a non-jeopardy BiOp. UCR spring Chinook are impacted in this section for safe passage through the PUD dams, not the CRS dams, but also experience an altered hydrograph from CRS storage reservoirs upstream.

Juvenile UCR Chinook Salmon Downstream Migration Through the CRS

UCR spring-run Chinook salmon populations pass all four lower Columbia CRS dams and three to five mid-Columbia River PUD dams on their downstream migration, depending on the stream of origin.

Past and present effects of CRS existence and operations: Through the CRS, juvenile UCR Chinook salmon have been and continue to be exposed to the effects of both CRS operations and the existence of the CRS dams. Juvenile UCR spring-run Chinook pass downstream of dams by many routes, including spillways, surface passage structures, intake screen bypass systems, and turbine units. Overall abundance and survival rates have increased since 2008. Major changes in dam configuration, operations (passage spill), and other actions have been taken since 2008 to achieve the 2008 BiOp performance standards and improve fish survival to 96 percent for spring migrants and 93 percent for summer migrants at each of the CRS projects (UCSRB 2019) (Table 3-35).

Table 3-35. Average fish passage efficiency and dam passage survival estimates for juvenile Chinook salmon passing CRS dams [based on Table D-1 and D-2 from Bonneville et al. (2018a)]

Dam	Year of Studies	FPE	Year of Studies	Average Survival Estimate
Bonneville (1st powerhouse)	NA	NA	2010	96
Bonneville (2nd powerhouse)	NA	NA	2011	96
The Dalles	NA	NA	2010, 2011	96
John Day	2012	93	2011, 2012	97
McNary	2012, 2014	97	2012, 2014	96

Past modifications of the dams include the installation of surface passage systems, improved turbine designs, and upgrades of intake screen bypass systems to improve how and where fish are returned to the river via outfalls downstream from dams, as well as new spill operations tailored to the unique structural configuration of each dam (Bonneville et al. 2017). A summary of those improvements is provided in Appendix A of Bonneville et al. (2017) and is incorporated by reference here. However, the actions that have benefitted UCR spring-run Chinook salmon include the following:

- Minimize winter drafts of the large upper basin storage reservoirs (for flood risk management and power generation) to save water for augmenting spring flows during the peak juvenile passage period (water quantity).
- Employ JBSs and surface passage structures and provide spill at the run-of-river dams to divert smolts away from turbine units and reduce potential delay in the forebays and minimize predation.
- Install replacement turbines with biologically based designs for safer fish passage than the case for the original units.
- Reduce TDG through multiple actions and plans.
- Manage avian and fish predators through multiple actions and plans.

For juvenile UCR Chinook salmon, annual mean survival from 1999 to 2018 has averaged 0.90 for the reaches from McNary Dam to John Day Dam and from John Day Dam to Bonneville Dam, while averaging 0.81 for the reach from McNary Dam to Bonneville Dam (Widener et al. 2019). However, if these estimates are broken into specific time periods, the average reach survival estimate from McNary Dam to John Day Dam for years 1999 through 2008 was 0.89, while from 2009 to 2018, it was 0.91. For the reach from John Day Dam to Bonneville Dam, for years 1999 through 2008 (there were no estimates in 2001, 2002, and 2005 for this reach) was 0.81, while from 2009 through 2018, survival increased to 0.95. For the reach from MCN to BON, survival from years 1999 through 2008 (there were no estimates in 2001, 2002, and 2005 for this reach) averaged 0.75, while from 2009 through 2018, average survival increased to 0.85 (Widener et al. 2019). While no studies have been completed to infer what caused the increase in survival since 2009, the timeframe is consistent with the implementation of a number of operational structural modifications undertaken specifically to improve downstream survival. The increased survival since 2009 suggests that those structural and operations changes at the dams are working.

Because survival of fish passing the dams via non-turbine routes is generally higher than through turbines, passage facilities are designed and operated to increase the likelihood of juvenile fish passage through non-turbine routes. The metric by which this is measured is FPE. Depending on the location and time of year, greater than 90 percent of juvenile spring-run Chinook salmon are using non-turbine routes at the four lower Columbia River dams (Bonneville et al. 2017).

Passage survival of UCR spring-run Chinook salmon at the lower Columbia River dams has been estimated to range from 95.6 percent at Bonneville Dam to 96.2 percent at The Dalles Dam (UCSRB 2019). Estimates represent overall survival from the upstream face of a given project to the tailrace mixing zone. Of the studies completed on lower CRS projects, 6 out of 7 met standards for yearling spring Chinook (Skalski et al. 2016). Results were below performance standards for yearling Chinook salmon at Bonneville Dam in 2011.

As discussed previously, Widener et al. (2019) compiled estimates of survival for juvenile Chinook salmon migrating downstream through the Snake and lower Columbia Rivers. However, those estimates included data for years preceding major physical and operational modifications to the CRS, and therefore the estimates of survival do not fully express the benefits realized by those modifications. Following structural and operational modifications implemented after the 2008 BiOp, survivorship improved through the CRS (Bonneville et al. 2017).

In addition, elevated TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can get forced into solution when water passes over the spillway at a mainstem dam, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019).

Past and present effects of predator management: Survival of UCR juvenile Chinook salmon is affected by avian and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple 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. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019).

Juvenile UCR Chinook Salmon Estuary Migration and Rearing, Including the Plume

The estuary provides important habitat for UCR spring-run Chinook salmon populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also impacted estuary ecosystems. For a more detailed discussion of estuary and plume conditions [see NMFS (2019)]. All of these conditions are part of the environmental baseline.

Past and present effects of CRS existence and operations: While there are no CRS facilities in the estuary (defined as Bonneville Dam to the ocean), past CRS management affected the timing and volume of flows, as well as temperature, sediment load, and TDG levels in this area. The effects of CRS management actions generally decreases as distance from Bonneville Dam increases and estuary hydrodynamics become less fluvially influenced. In particular, flow regulation and reduced sediment recruitment caused by the CRS have likely negatively affected habitat forming processes in the estuary, habitats which support the juvenile life stage of all Columbia River Basin anadromous fish populations.

Estuarine floodplain habitat is important for out-migrating juvenile salmon and spring-run Chinook salmon, including UCR Chinook salmon. To help maintain and improve the overall status of salmon and spring-run Chinook salmon in the Columbia River Basin, the Action Areas actively work to restore and conserve habitat in the Columbia River estuary. These restoration actions affect salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit is that wetland food production supports foraging and growth within the wetland (Johnson et al. 2018). Prey items (primarily chironomid insects and corophiid amphipods; PNNL/NMFS (2018) produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and spring-run Chinook salmon migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest 5-year review, have improved access and connectivity to floodplain habitat. From 2004 through

2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide-gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity below Bonneville Dam (Johnson et al. 2018). In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past and present effects of predation management: A variety of avian species (especially Caspian terns and Double-crested cormorants), have historically been a major source of predation on juvenile salmonids in the estuary. While avian predators continue to prey upon juvenile salmonids, including MCR spring-run Chinook salmon, predation rates have declined due to a variety of management efforts. For example, between 2007 and 2010, the average predation on MCR spring-run Chinook salmon by Caspian terns and Double-crested cormorants from East Sand Island (near the mouth of the Columbia River) was approximately 15% and 10%, respectively (Evans et al. 2018). However, from 2011 to 2017, the average for Caspian terns dropped to 9.1%, and 5.5% for Double-crested cormorants (Evans et al. 2018). The efforts to reduce avian predation are discussed in detail within the 2019 BiOp and are incorporated by reference here (NMFS 2019). NMFS (2019) noted the success of implementing the avian management plans at meeting underlying goals; however, the success may be uncertain at this time because birds have relocated to other areas within the estuary.

Ocean Rearing

UCR Chinook salmon typically spend 2 years rearing in the ocean (NMFS 2009). Variability in marine ecosystem productivity can be the major factor determining adult Chinook run size (NMFS 2014a). In the most recent adult return years since about 2014, poor ocean conditions have contributed to declines in ocean survival and associated adult returns. In the 2019 BiOp, NMFS provides a detailed discussion on ocean conditions, factors that affect the ocean environment, and impacts to UCR Chinook; that information is incorporated here by reference. However, the following is a brief summary of those factors.

Factors that influence ocean productivity are also likely to affect the survival of UCR Chinook. The projected increase in air temperature due to climate change, which will likely increase water temperature and alter productivity, severe El Niño events, worsening ocean acidification, and major alterations in the northeast Pacific Ocean marine ecosystem associated with the PDO (NMFS 2019) will affect survival either directly or indirectly because of their deleterious impacts on marine food webs.

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in distribution of aquatic marine organisms. Many species that typically occur in more southerly waters, moved northward from southern California to Alaska in the unusually warm water during 2014 and 2015, which was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Pearcy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt marine ecosystems in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean and past CRS operations have had little or no direct effect on this ESU during ocean residence. In a recent

review, Welch et al. (2018) concluded that marine survival of west coast Chinook and spring-run Chinook salmon populations has collapsed over the last half century for most regions of the west coast. Based on their review of annual survival estimates for Chinook and spring-run Chinook salmon, they concluded:

We found that marine survival collapsed over the past half century by a factor of at least 4–5 fold to similar low levels (~1%) for most regions of the west coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Past and present effects of harvest: Spring-run Chinook are not targeted by ocean fisheries, and harvest is assumed to be near zero (NMFS 2019).

Adult UCR Chinook Salmon Migration to Bonneville Dam

Adult spring-run Chinook salmon migrate upstream after ocean residence and do not feed within the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume, and a migratory corridor free of obstructions to access spawning areas (NMFS 2019). Populations of UCR spring-run Chinook enter the Columbia River estuary and pass over Bonneville Dam between March 15 and May 31 (UCSRB 2019).

For upstream migrating UCR spring-run Chinook salmon, the primary factor affecting survival through the estuary to Bonneville Dam is likely pinniped predation. As noted by UCSRB (2019), NOAA fisheries modeling of pinniped predation has shown a trend of decreased survival for studied spring Chinook populations. Survival reductions for the earliest arriving spring Chinook in recent years were the greatest, including Methow River spring-run Chinook (22 percent) compared to intermediate arriving populations like the Entiat and Wenatchee River spring Chinook (11 percent) relative to late-arriving populations (UCSRB 2019). For the early-arriving Methow River spring Chinook, an estimated 35 percent of the returning adult population was lost to predation between the estuary and Bonneville Dam in 2015 [Sorel et al. (2017) as cited in UCSRB (2019)] Predation rates have declined over the last 2 years. Pinniped injury rates noted at Bonneville Dam for spring Chinook and spring-run Chinook salmon have varied from 11 to 37 percent [1999–2005; Scordino (2010) as cited in UCSRB (2019)].

Past and present effects of CRS dams and operations: There are no CRS dams that impede migration in the lower Columbia River, as these fish migrate upstream to Bonneville Dam. UCR spring-run Chinook migrate upstream through the estuary and arrive at Bonneville from mid-March to the end of May. It is possible that elevated TDG levels may influence migratory behavior. TDG levels are attenuated downstream from Bonneville Dam by gas dissipation and the mixing of water with low TDG levels from tributaries such as the Willamette River.

Past and present effects of harvest: Harvest mortality in fisheries has been reduced compared to mortality that occurred before the 1990s (U.S. v. Oregon 2008). The incidental take observed from 2008 to 2017 ranged from 8.8 to 16.7 percent, with an average of 12.1 percent. In the 2018–2027 U.S. v. Oregon Management Agreement of the Columbia River, incidental harvest of UCR spring-run Chinook is

limited to 17 percent of the estimated run size at the mouth of the Columbia River (U.S. v. Oregon 2018).

Adult UCR Chinook Salmon Migration Through the CRS Dams

UCR spring-run Chinook salmon populations migrate upstream through the four lower CRS projects, and through three to five PUD projects on their way to natal spawning areas. During upstream migration, these fish experience a variety of factors affecting the adult migration life-stage, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish [NMFS (2008b); Keefer et al. (2016); and Keefer and Caudill (2017) as cited in NMFS (2019)]. The primary factors influencing safe, timely, and effective adult upstream passage through CRS dams are tailrace flow dynamics, sufficient attraction flows to fish ladder entrances, operating ladders within criteria, reducing fallback, and maintaining safe ladder temperature and differentials (NMFS 2019).

Past and present effects of CRS existence and operations: Under typical conditions, after accounting for reported harvest rates and expected stray rates, adult UCR spring-run Chinook typically have relatively high conversion rates¹⁶ passing the four lower Columbia River CRS dams (NMFS 2019). Based on conversion rates of PIT-tagged UCR spring-run Chinook salmon detected at Bonneville Dam for the years of 2008 to 2017, the minimum estimate of survival for the Bonneville to McNary reach averaged 91.5 percent over the 10-year period (range of 80.4 to 105.1 percent). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 97.1 percent per project (NMFS 2019). These estimates of minimum survival also account for impacts associated with fallback at the lower Columbia River CRS projects, such as direct and indirect mortality associated with the fallback event, delay, straying, etc.

Past and present effects of predator management: As discussed previously, the presence of pinniped predators has increased within the Bonneville Dam tailrace in recent years, with occasional pinniped observations in the Bonneville reservoir [Tidwell et al. (2018) as cited in NMFS (2019)]. To restrict entry of pinnipeds into the ladder systems at Bonneville Dam, the Corps constructed structures to physically exclude pinniped entry into fishways, while allowing upstream migration of adult salmonids. These structures have been installed at all eight fishway entrances at Bonneville Dam (NMFS 2019).

Past and present effects of harvest: The 2008 U.S. v. Oregon Management Agreement has allowed an incidental take of UCR spring-run Chinook salmon of 5.5 to 17.0 percent. For the years of 2008 to 2017, incidental take was estimated to average about 12.1 percent, with a range of 8.8 to 16.7 percent (U.S. v. Oregon 2018). Most of the harvest on UCR spring-run Chinook salmon occurs in Columbia River mainstem tribal gillnet and dip net fisheries.

¹⁶ Conversion rates are simply the percentage of adult salmonids passing an upstream dam that passed a downstream dam (# passing upstream dam/# passing downstream dam). Conversion rate is used as a surrogate for survival, but other factors (than mortality) may affect the number of adult fish passing the upstream dam (e.g., tag not detected), so a conversion rate is not specifically an accurate measure of survival.

Adult UCR Chinook Salmon Migration Upstream of the CRS to the Spawning Areas

Within the UCR tributaries that support the spawning and rearing of UCR spring-run Chinook salmon populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

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 to natal spawning areas for adult UCR spring-run Chinook salmon.

Past and present effects of harvest: Spring-run Chinook from the UCR spring-run Chinook ESU are not harvested in tributary fisheries upstream from Priest Rapids Dam (in some years, there is harvest of spring-run Chinook salmon in the Wenatchee River and Icicle Creek, but that fishery is focused on returning hatchery fish from the Leavenworth National Fish Hatchery, which are not ESA-listed).

STATUS OF CRITICAL HABITAT

This section reviews the status of critical habitat for UCR spring-run Chinook salmon. Critical habitat includes the stream channels within designated stream reaches and, to an extent, is defined by the ordinary high-water mark (33 CFR § 319.11). The PBFs of critical habitat that are essential to the conservation of UCR spring-run Chinook have been identified and include freshwater spawning, rearing, and migration areas, as well as estuarine and nearshore marine environments (Table 3-36) (NMFS 2019).

On September 2, 2005, (70 FR 52630 ; NMFS 2019) designated critical habitat for UCR spring-run Chinook salmon in the Interior Columbia recovery domain, which encompasses all of the Columbia River Basin accessible to anadromous salmon and spring-run Chinook salmon above Bonneville Dam. The UCR spring-run Chinook ESU spawns and rears in major tributaries between Rock Island Dam and Chief Joseph Dam. As juveniles and adults, they migrate through the Columbia River between the Columbia River mouth and the Wenatchee, Entiat, and Methow River Basins, depending on population in the MPG.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline conditions for PBFs; however, the conservation 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 UCR spring-run Chinook salmon.

Table 3-36. Physical and biological features of critical habitats designated for UCR spring-run Chinook salmon and the components PBFs (NMFS 2019)

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
Freshwater spawning sites	Water quantity and quality conditions and substrate-supporting spawning, incubation, and larval development	<p>Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage)</p> <p>Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage)</p> <p>Diminished streamflow (degraded water quantity, elevated temperatures, loss of juvenile and adult mobility)</p> <p>Impaired fish passage (obstructions, water withdrawals)</p> <p>Excess fine sediment in spawning gravel (degraded water quantity)</p> <p>Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation)</p>
Freshwater rearing sites	<p>Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility</p> <p>Water quality and forage supporting juvenile development</p> <p>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</p>	<p>Impaired fish passage (obstructions, water withdrawals)</p> <p>Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations)</p> <p>Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)</p> <p>Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage)</p>
Freshwater migration corridors	Free of obstruction and excessive predation 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	<p>Delay and mortality of adults (at up to eight mainstem dams)</p> <p>Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human built structures used by terns and cormorants for nesting)</p>
Estuarine areas	<p>Free of obstruction and excessive predation, with:</p> <p>Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater</p> <p>Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels</p> <p>Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation</p>	Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage) and the presence of toxic contaminants (reduced water quality and forage).

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
Nearshore marine areas ^a	Free of obstruction and excessive predation, with: Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation	Concerns about increased opportunities for pinniped predators and adequate forage
Offshore marine areas	Not designated	

^a The designated nearshore marine area includes the mouth of the Columbia River, an imaginary line connecting the outer extent of the north and south jetties.

Adult UCR spring-run Chinook salmon begin returning from the ocean in the early spring, with the peak of the run into the Columbia River in mid-May (UCSRB 2007). They enter UCR tributaries from April through July, where they will hold until spawning occurs in August–September. Migration of UCR spring-run Chinook salmon through the CRS and areas upstream is complicated because of various environmental factors that affect migration.

Freshwater Spawning and Rearing Sites

UCR spring-run Chinook spawn in gravel and cobble substrates that are largely free of fine sediments. Developing eggs require cool, clean, and well-oxygenated waters for proper development. Juveniles spend a year in freshwater before migrating to the ocean in the spring of their second year of life. During their freshwater residence, juvenile salmon need abundant food sources and instream cover to protect them from predators. Juvenile fish cover may include undercut banks, overhanging vegetation, logs and root wads, and large substrate (NMFS 2019). Off-channel habitat, side channels, and other low-stream-velocity areas provide refuge during high-flow events. Cool waters in springs, seeps, and deep pools offer refuge when stream temperatures increase during the summer. Interstices offered by large substrate allows juveniles to seek refuge during the winter.

The quality of tributary habitat for UCR spring-run Chinook varies substantially throughout the UCR region with some spawning and rearing habitats in near pristine condition, while other areas are minimally to highly degraded due to past human activities (NMFS 2019). Habitat throughout the interior Columbia River Basin tributaries has been degraded by numerous human activities, including 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, timber harvest, mining, and urbanization [Lee et al. (1997) as cited in NMFS (2019)]. These activities have led to factors that limit the viability of UCR spring-run Chinook. These factors include (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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (Mullan et al. 1992; Chapman et al. 1994; Chapman et al. 1995; Maier 2014; RTT 2014).

Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel instability are common symptoms of ecosystem decline in areas of critical habitat. Lack of adequate summer streamflows, impaired water quality, and reduction of habitat complexity are common

problems for critical habitat in developed areas of the interior Columbia Basin. Large-scale habitat assessments in the interior Columbia Basin indicate that in watersheds managed for natural resources extraction, the number of large pools has decreased from 87 to 20 percent compared to watersheds not being managed for natural resources extraction [McIntosh et al. (1994) as cited in NMFS (2019)].

To address these issues and to mitigate impacts associated with the operation of the CRS, the Action Agencies, in cooperation with private, local, state, tribal and federal entities have implemented a variety of tributary habitat restoration actions throughout the upper Columbia River region to benefit UCR spring Chinook salmon since 2007. Those restoration actions are summarized in Table 3-37.

Table 3-37. Tributary habitat improvement metrics: UCR spring-run Chinook salmon, 2007–15 [reproduced from NMFS (2019); Table 2.11-6]

Action Type ^a	Amount Completed
Acre-feet/year of water protected <i>(by efficiency improvements and water purchase/lease projects)</i>	23,708.8
Acres protected <i>(by land purchases or conservation easements)</i>	283.5
Acres treated <i>(to improve riparian habitat, such as planting native vegetation or controlling noxious weeds)</i>	356.6
Miles of enhanced or newly accessible habitat <i>(by providing passage or removing barriers)</i>	110.4
Miles of stream complexity improved <i>(by adding wood or boulder structures or reconnecting existing habitat, such as side channels)</i>	21.8
Miles protected <i>(by land purchases or conservation easements)</i>	8.32
Screens installed or addressed <i>(for compliance with criteria or by elimination/consolidation of diversions)</i>	10

^a Several of these categories (i.e., acres protected, acres treated, miles of enhanced stream complexity and miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

In the 2019 BiOp, NMFS (2019) concluded the following:

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have 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 ISAB (2015) has pointed out that there is compelling evidence for strong density dependence at current abundance levels for anadromous salmon and suggested that habitat capacity has been greatly diminished. The ISAB also suggests that changes in environmental conditions within habitats accessible to salmon and spring-run Chinook salmon stemming from climate change, chemicals, and intensified land use appear to have further diminished habitat capacity. Density dependence is also occurring within the major subbasins where UCR spring-run Chinook salmon spawn and rear (ISAB 2015). In the Wenatchee and Entiat River Basins, there is a definite negative trend in productivity with higher

spawner abundance (ISAB 2015). For the Methow River Basin, the relationship appears to be influenced by a single observation at higher spawner abundance.

ISAB (2015) noted that studies of density dependence during the spawning and incubation stage are rare. In addition, other factors such as sedimentation, streamflow, water temperatures, and winter freezing conditions can be responsible for significant mortality during spawning and incubation. Strong density-dependent survival of juveniles has been reported in populations of spring/summer Chinook (ISAB 2015). ISAB (2015) also suggested that in some of the populations, the strongest density dependence occurred in populations with the highest level of anthropogenic disturbance. And, while few studies have examined the main cause of the observed density dependence (i.e., limitations in spawning vs. rearing habitat) in spring-run Chinook salmon, what studies there are suggest that the effect is most likely related more to interactions during rearing than during spawning stages, although further study is necessary to confirm this.

Key recommendations from ISAB (2015) included (1) account for density effects when planning and evaluating habitat restoration actions; (2) establish biological spawning escapement objectives that account for density dependence; (3) balance hatchery supplementation with the basin's capacity to support existing natural populations by considering density effects on the abundance and productivity of natural origin salmon; and (4) improve capabilities to evaluate density-dependent growth, dispersal, and survival by addressing primary data gaps.

Freshwater Migration Corridors

The freshwater migration corridor extends from the spawning and rearing areas in the UCR subbasins downstream to the Columbia River plume. Migration corridors are essential to the conservation of UCR spring-run Chinook salmon. Human activities that have affected habitat in subbasin tributary reaches have already been discussed and contribute to the quality and quantity of water downstream and within the migration corridor. Tributary habitat actions already implemented support all MPGs of UCR spring-run Chinook and have reduced migration obstructions, increased water quantity, improved water quality, and improved cover (see Table 3-37). In tributary reaches of the Columbia River, UCR spring-run Chinook are not exposed to any CRS operations until they reach the mainstem Columbia River.

The quality of designated critical habitat within the Columbia River migration corridor is a function of the cumulative impacts of upstream actions, including impacts from development along the corridor, dam existence and operations, and management within the Columbia River that affects both juvenile and adult UCR spring-run Chinook salmon. All these factors combine to affect critical habitat in the mainstem and influence the migration corridor. Water management projects affect four major habitat factors in the mainstem migration corridor: water quality, ecosystem structure and function, flow, and reduced upstream and downstream fish passage survival (UCSRB 2007). (NMFS 2019) describes factors affecting the behavior and survival of UCR spring Chinook salmon through the CRS. This information is incorporated here by reference NMFS (2019). The following is a brief summary of those factors.

Mainstem CRS dams and dam operations can affect stream temperature, streamflow, gas supersaturation levels, river habitats, and other features. Both the Snake and Columbia Rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Because the temperature regime has been modified,

resulting in warmer late summer/fall water temperatures, it potentially affects juvenile and adult salmonids as well as fish community structure. Warmer stream temperatures may influence predation rates on juvenile fish by predatory fish species. Juvenile fish may also be affected when water is spilled from hydroelectric facilities that increase gas supersaturation and may lead to GBT in fish. All projects create impoundments that affect riverine habitats and can affect travel times, which in turn may increase juvenile fish exposure to both native and non-native predators. Some passage routes through dams may decrease juvenile fish survival (e.g., turbines) compared to spill bays and surface passage routes that are operated to increase overall juvenile passage survival. The processes, general effects, and mitigation of CRS mainstem dams and dam operations on the functioning of critical habitat are shown in Table 3-38.

Table 3-38. The processes and effects of the CRS dams and dam operations and mitigation efforts to address the effects

Process	Effect	Avoidance, Minimization, or Mitigation Measure
Passage at dams	Reduced juvenile survival due to the existence of the dams (baseline), recent improvements in survival since CRS overhaul	Surface passage, increased proportion of spill, flow augmentation, TDG management, bypasses, and fish-friendly turbines
Water storage operations	Altered water quantity and seasonal timing	Flow augmentation
Solar radiation/reduction in mainstem stream velocity	Altered temperature for late summer and fall fish migrants, both in the reaches below the large mainstem storage projects and migration corridors	The dams result in water temperatures that are slightly better (cooler) during the spring migration
Water storage	Reduced sediment transport and turbidity in migration corridors and estuary due to dam existence and to a lesser extent the ongoing operations of the CRS	
Spill	Increased TDG	System-wide TDG management
Modification (impoundment and water level fluctuation) of mainstem migratory and rearing habitat	Altered food webs, including both predators and prey due to the existence of the dams and to a lesser extent the ongoing operations of the CRS	Avian management, fish bypass outfall placement (away from known predator concentrations), and pikeminnow removal (management)

Since 2008, modifications to the physical and operational CRS system have been implemented based on the NMFS (2008b) BiOp. Presumably due in large part to these modifications, survival of juvenile UCR spring-run Chinook salmon and adult migrants has improved substantially. As noted earlier, survival from years 1999 through 2008 (there were no estimates in 2001, 2002, and 2005 for this reach) averaged 0.75, while from 2009 through 2018, survival increased to 0.85 (Widener et al. 2019).

For adult UCR spring-run Chinook salmon for the years of 2008 to 2017, the estimate of minimum survival for the Bonneville to McNary reach averaged 91.5 percent over the 10-year period (range of 80.4 to 105.1 percent). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 97.1 percent per project (NMFS 2019).

Estuarine and Nearshore Marine Areas

Critical habitat has been designated for UCR spring-run Chinook salmon in the Columbia River estuary (NMFS 2019). NMFS has defined the estuary to include the tidally-influenced portion of the Columbia River, i.e., from Bonneville Dam (RM 146) to the mouth of the Columbia River, including the lower portions of tributaries influenced by tidal action. As such, the lower 26 miles of the Willamette

NMFS (2019) considers a functioning estuary essential to the conservation of UCR spring-run Chinook salmon. NMFS identified the PBFs for UCR spring-run Chinook salmon in the estuary to include areas free of obstruction with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between freshwater 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.

NMFS (2019) identified degraded habitat conditions in the estuary as a limiting factor for UCR spring-run Chinook salmon. Historically, the Columbia River estuary was more dynamic than it is today. Multiple channels, extensive wetlands, sandbars, and shallow areas, especially in the downstream 50 river miles, were influenced by winter and spring floods, low flows in late summer, large woody debris, and high sediment loads (NMFS 2019). As reported by NMFS (2019), the current conditions of the Columbia River estuary have changed as a result of many factors, including dredging to deepen and maintain the Federal Navigation Channel and the existence of jetties and pile-dike fields to stabilize and concentrate river flow. Causeways have been constructed across waterways. As noted by NMFS (2019), the mouth of the Columbia River was historically about 4 miles wide but has decreased to about 2 miles wide, and the depth has increased at the Columbia River channel at the bar from less than 20 feet to more than 55 feet.

In particular, (NMFS 2019) NMFS (2019) reported a dramatic decrease in wetland areas associated with the Columbia River estuary. More than 50 percent of the marshes and spruce swamps have been converted to industrial, transportation, recreational, agricultural, or urban areas, with more than 3,000 acres converted since 1948 (NMFS 2019). In the upper reaches of the estuary, many wetlands along the shore have been converted to industrial and agricultural lands after levees and dikes were constructed. As reported by NMFS (2019), 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost since the late 1800s. Those wetlands support salmonid food webs both in shallow water and in the mainstem.

Changes in streamflow and sediment delivery have also affected critical habitat in the Columbia River estuary. NMFS reports that water storage and release patterns from reservoirs upstream have changed the seasonal pattern and volume of discharge within the Columbia River estuary (NMFS 2019). Discharge has increased in the winter and peak spring/summer floods have been reduced. NMFS (2019) also reported that model studies indicate that combined human activities in the Columbia Basin have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine-sediment transport by 50 percent or more. The significance of changes in sediment delivery to UCR spring-run Chinook salmon is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean [Johnson et al. (2018); PNNL/NMFS (2018); and Weitkamp (2018) as cited in NMFS (2019)].

In terms of critical habitat, there are no CRS-related barriers to migration in the estuary, and there is no evidence that flows are insufficient for migration.

PROPOSED ACTION COMPONENTS SPECIFIC TO UCR SPRING-RUN CHINOOK SALMON

The Proposed Action, continuing to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2 of this document and associated appendices as modified by the flex spill Letter to NOAA. Reclamation is also consulting on the Columbia River mainstem effects of six irrigation projects that also have additional and separate ESA reviews.¹⁷ This Proposed Action continues extensive operations that benefit UCR spring-run Chinook salmon, including flow augmentation, spill, surface passage, bypasses, and adult ladder operations. In addition, mitigation activities that have been implemented as part of previous BiOps will continue, including tributary and estuary habitat improvements; fish, avian, and pinniped predator management; and conservation and safety-net hatcheries—all as described in Chapter 2 of this document. The Action Agencies will continue to coordinate with regional sovereigns and will regularly update the water management, fish passage, fish operations, and water quality plans. The Action Agencies intend to implement these actions commencing in September 2020.

UCR spring-run Chinook salmon are likely to experience effects associated with exposure to following aspects of operating and maintaining the CRS:

- Water quantity and quality changes in the mainstem Columbia River from the confluence of the Snake River to the ocean, passage through four CRS dams in both the downstream and upstream migrations.

Operational conservation measures that are part of the Proposed Action includes: flow augmentation; voluntary spill regimes at eight dams; cooling water releases from Dworshak Reservoir during the summer migration period; juvenile fish transportation; fish facility operations at eight dams (bypasses, ladders, surface structures, outfalls, etc.); fish friendly turbines at McNary and Ice Harbor dams; avian, fish, and pinniped predator management; tributary habitat actions linked to the UCR spring-run Chinook salmon ESU; and estuary habitat actions. It is important to note that since UCR spring-run Chinook salmon do not migrate in the Snake River, that there are only four dams (lower Columbia River) where spill, facility improvements, and fish friendly turbines (only McNary Dam) will affect UCR spring-run Chinook salmon.

EFFECTS OF THE ACTION ON UCR SPRING-RUN CHINOOK SALMON ESU

The effects of the existence of the dam and reservoir system, and past operations, are part of the baseline and are not considered effects of the Proposed Action. Construction of dams throughout the

¹⁷ Columbia River mainstem effects of certain Reclamation irrigation projects are included in this CRS consultation because the Columbia River hydrologic modeling incorporates all such impacts. The mainstem Columbia River impacts are included for the Yakima, Umatilla, Deschutes, and Crooked River irrigation projects. UCR spring-run Chinook salmon do not spawn or rear in any of these tributaries. However, the flow impacts of these projects to the mainstem Columbia River are fully integrated in discussions of flow and TDG in the parts of the migratory corridor used by this ESU is impacted by these projects.

Columbia River Basin, including those associated with the CRS, established a new hydrograph in the Columbia River that differs from historic conditions; however, the Proposed Action will not result in further degradations, and, in fact, is actively operating to more closely mimic historic conditions while ensuring that other authorized purposes, including flood risk management requirements are maintained.

The main effects of continuing to operate and maintain the CRS on UCR spring-run Chinook salmon include supporting downstream and upstream passage through the CRS mainstem lower Columbia River dams, which are part of the environmental baseline. This can include any delayed or latent mortality that may occur as a result of how operating the dams affects salmon and steelhead passage at the dams. Action effects also include changes in fish travel time based on upriver reservoir storage operations, as well as potential exposure to elevated TDG from voluntary spill. Improving juvenile and adult migration survival has been the focus of mitigation actions under past BiOps, and the benefits of these actions have been thoroughly documented [Corps et al. (2017a); Bonneville et al. (2018a), Appendix D]. These already-completed actions will continue to provide benefits in the future. The effects of the Proposed Action on this ESU and its critical habitat are described by life-stage below.

Freshwater Spawning, Rearing, and Migration to the CRS

In the spawning and rearing areas, fish are not exposed to the effects of operations (e.g., flood risk management, irrigation, power generation). Because there is no exposure to these operations that are components of the Proposed Action, there are no direct effects from managing the CRS to individual fish in these areas.

Some individual fish of this ESU are exposed to habitat improvements through the Tributary Habitat Improvement Program as a component of the Proposed Action. UCR spring-run Chinook salmon will benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that will result from the tributary actions. Adverse effects to individuals from actual implementation (i.e., construction) of habitat enhancement actions are mitigated through compliance with the Tributary HIP's BiOps (NMFS 2013; USFWS 2013). The tributary habitat improvements are proposed for the Wenatchee, Entiat, and Methow Rivers, which make up the one major population group for this ESU, and include, among other actions, streamflow protection and enhancement, improved habitat access, improved stream complexity, improved riparian habitat, and improved screening to reduce entrainment, all of which continues to improve habitat condition.

Juvenile UCR Spring-run Chinook Salmon Downstream Migration Through the CRS

Juvenile UCR spring-run Chinook salmon are not exposed to the effects of CRS operations until they reach the mainstem Columbia, and as they pass through four to nine dams (five of which are owned and operated by PUDs), depending on their subbasin of origin. In this migration corridor, juvenile UCR spring-run Chinook salmon will continue to experience the deleterious impacts of a degraded environmental baseline, including the existence of dams, and associated cumulative effects.

In general, the Proposed Action will continue operations and implement actions to minimize impacts from both baseline conditions and the action, and thus increase survival of juvenile UCR spring-run Chinook salmon that pass through the CRS. Measures that have been implemented and will continue

include flow augmentation to decrease migrant travel time, voluntary spill and other measures to direct juveniles away from turbines (e.g., through spill, surface passage and other juvenile bypasses), safer turbine passage, and predator management.

Operations and structural improvements have been modified by previous actions to the specific conditions and structure of each dam to reduce the proportion of juvenile fish that passes through turbines, reduce forebay passage delay, and improve overall dam passage survival (Corps et al. 2017a).

Changes in the Proposed Action compared to past operations include a flex-spill operation and changed implementation of summer spill. Because juvenile UCR spring-run Chinook salmon do not migrate during the summer, any changes in summer spill will not affect this ESU. Changes to spring spill could result in an increased juvenile passage survival for UCR spring-run Chinook salmon that are passing through the CRS and decreased latent mortality.

A more detailed analysis of effects on UCR spring-run Chinook salmon as a result of implementing the Proposed Action during downstream migration through the CRS is described below. The indicators that will be used to determine the effects of the Proposed Action on juvenile spring-run Chinook salmon migration through the CRS are discussed in the following sections.

Operational

The EIS COMPASS modeling results¹⁸ support the anticipated results of the qualitative analysis that found that juvenile UCR spring-run Chinook salmon survival rates from McNary Dam to Bonneville Dam would increase from the Proposed Action compared to the current condition. The COMPASS model predicted that survival could increase about 1.5 percent (Table 3-39). Juvenile travel time and powerhouse passage encounters through the lower CRS would both decrease for juveniles compared to current conditions (Table 3-39). Modeling changes in TDG suggest that the average exposure will increase for MO4 by almost 4 percentage points and TDG-related survival will decrease (Table 3-39).

Table 3-39. Juvenile model metrics for UCR spring-run Chinook salmon. The model metrics for MO1 and MO4 represent a range of potential changes from the No Action Alternative (NAA). Percent change is included for the model metrics compared to the NAA.

Metric (Model)	NAA 2016 Ops	MO1		MO4		Range
		Value	Percent Change from NAA	Value	Percent Change from NAA	
Juvenile Survival (COMPASS)	69.5%	70.0%	0.72%	71.0%	2.15%	1.5%
Juvenile Travel Time (COMPASS)	6.1 days	5.8 days	4.92%	5.3 days	13.11%	0.8 days
Powerhouse Passages (COMPASS)	3.29	3.08	6.38%	2.53	23.10%	0.76

¹⁸ The CSS model was not employed for UCR species.

Metric (Model)	NAA 2016 Ops	MO1		MO4		Range
		Value	Percent Change from NAA	Value	Percent Change from NAA	
TDG Average Exposure (TDG Tool)	115.8% TDG	115.8% TDG	0.00%	119.5% TDG	3.20% TDG	3.70
TDG-related Juvenile Survival	98.3%	98.3%	0.00%	95.7%	2.64%	2.60%

Survival at CRS Dams

Survival of juveniles once they enter the Columbia River is influenced by a suite of factors, such as water quality (e.g., temperature, TDG), passage at dams, predators, fish travel time, etc. Survival studies show, with few exceptions, that measures implemented through the previous BiOps, and continued into the current Proposed Action, performed as desired and have, or are very close to achieving, the 2008 BiOp juvenile dam passage survival objective of 96 percent for juvenile spring-run Chinook salmon (NMFS 2017e). For example, for juvenile yearling Chinook salmon (no stock-specific estimates are available), dam passage survival has ranged from 95.7 percent to 97.6 percent at Bonneville Dam, while ranging from 96.0–96.4, 97.4–98.7, 96.9–99.1 percent, at The Dalles, John Day, and McNary dams, respectively (Bonneville et al. 2017). These numbers have improved substantially when compared to dam passage survival prior to the overhaul of the system after 2008. Implementation of the Proposed Action is expected to maintain or improve survival of UCR spring Chinook migrating through the system and reduce latent mortality after they pass Bonneville Dam. The COMPASS model estimates that juvenile survival could increase 1.5%.

While turbine survival is generally lower than spillway survival, bypass and sluiceway survival can be close to, equal to, or even greater than spillway survival in terms of direct dam survival. The COMPASS model relies on juvenile route-specific survival estimates and predicts the increase in spill (flexible spill up to 125 percent TDG) will result in an increase in juvenile UCR spring-run Chinook salmon reach survival passing up to nine dams. It is important to note that since higher spill levels result in unbalanced energy and 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; however, most predictions are for increased survival.

Mainstem CR Fish Travel Time

Under the flex spill plan, spring spill operations at the eight fish passage dams will spill to state water quality limits (anticipate 125 percent starting in 2020) for 16 hours per day and performance spill for 8 hours per day. The performance spill patterns and amounts were developed using a combination of 2008 FCRPS BiOp prescribed spill and performance standard testing guidelines, and gas cap spill uses spill up to state water quality standards with some restrictions for erosion concerns and powerhouse minimums. The main effects of the higher spill are a decrease in forebay delay and an increase in spill passage efficiency, with a hypothesized (reduction in) latent mortality (NMFS 2019). This results in shorter forebay residence times. Modeling results estimate that fish travel time from McNary Dam to Bonneville Dam will be slightly reduced. Additional flow through the spill bays will likely draw a greater

proportion of juvenile spring-run Chinook salmon migrants from the powerhouse routes (turbine and bypass) and surface passage routes (surface weir and sluiceway). The model estimate suggests that implementation of the Proposed Action could decrease juvenile travel time by approximately 5–13%. Decreasing smolt travel time with higher levels of spill through the CRS can provide a survival advantage due to reducing exposure time to predators and fostering a more normative synchrony between the physiological process of smolt transformation and the timing of seawater entry.

Powerhouse Passage Proportion

In addition to increasing spill in the spring, the Action Agencies propose to modify spillway weirs and turbines at John Day Dam. These actions to improve the baseline structural conditions are anticipated to increase the survival of juvenile fish that pass through those routes. In addition, increasing the proportion of water discharged as spill directs a higher fraction of migrants away from the powerhouse and toward the less hazardous spillway. This reduces smolt encounters with turbines and screened bypass system, both of which have been implicated in contributing to latent mortality as expressed in the marine environment. It is also possible that reduction in powerhouse encounters results in reductions in latent mortality leading to increased survival during later life stage development in the estuary and marine environments. The model predicts a potential decrease in powerhouse encounters by 23%, which could benefit UCR spring-run Chinook salmon.

Total Dissolved Gas

Spill at CRS dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. This may occur during periods of high flows (involuntary spill) or purposely for set periods of time as result of the Proposed Action. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids that may result in injury or death. Survival of juvenile salmonids can be reduced when TDG levels exceed lethal limits and fish are not able to compensate by swimming into deeper water (Beeman and Maule 2006).

Biological monitoring within the CRS shows that the incidence of GBT in both migrating smolts and adults remains between 1–2% when TDG concentrations in the upper water column do not exceed 125% of saturation (Antcliffe et al. 2002; Backman et al. 2002; NMFS 2019). When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. McGrath et al. (2006) determined that research supports previous research indicating that short-term exposure to up to 120% TDG does not produce significant effects on juvenile (or adult) salmonids when compensating water depths are available (Beeman and Maule 2006; NMFS 2019). Therefore, it is anticipated that increases in TDG as a result of implementing the flexible spill operation will result in negligible increases in GBT to outmigrating juvenile UCR spring-run Chinook salmon through the CRS, because the Proposed Action is not intended to exceed the 125% “gas cap” during periods of voluntary spill.

Temperature Changes

Temperature changes can cause stress and mortality to UCR spring-run Chinook salmon. Temperature influences growth and feeding rates, metabolism, development, migration timing, and the availability of food. In addition, temperature plays a role in predator fish behavior, which also affects juvenile salmonid survival.

Current temperature conditions are different from historic as a result of a suite of anthropogenic activities as described in the status of the species section, but are generally not elevated sufficiently to be detrimental to UCR spring-run Chinook during the time juvenile UCR spring Chinook are actively migrating downstream through the system. The Proposed Action is not anticipated to change the current temperature regime in the river during the time that UCR spring-run Chinook salmon juveniles are outmigrating through the CRS. Therefore, it is anticipated that temperature changes attributable to the Proposed Action are likely indistinguishable from current conditions and will result in negligible effects to outmigrating juvenile UCR spring-run Chinook salmon.

Turbidity Levels

Development of the CRS (and other non-federal dams) has reduced sediment transport from historic levels, and subsequently reduced turbidity by having suspended particles in the water fall out when the water enters a slower moving reservoir. These conditions are part of the environmental baseline. Lowered turbidity levels may increase the susceptibility of juvenile UCR spring-run Chinook salmon to avian and piscivorous predators due to increase visibility in the water column. Avian predation is most likely to occur in the tailrace of the dams, while piscivorous predation may occur in both the forebay and the tailrace. Implementing the Proposed Action is unlikely to result in changes in the amount of suspended solids (and resulting turbidity) in the water column through the CRS. However, while outmigrating juvenile UCR spring-run Chinook salmon will continue to experience a less turbid system as a result of past actions, the Proposed Action does include measures to address these impacts in the vicinity of the dams as described in the next subsection (predation).

Predation

A variety of bird and fish predators consume juvenile UCR spring-run Chinook salmon on their migration from tributary rearing areas to the ocean. Existing conditions create habitat that is more ideal for both native and non-native predatory fish. Outmigrating juvenile UCR spring-run Chinook salmon encounter these predatory fish as they pass through the reservoirs and tailraces of the CRS. Implementing the Proposed Action will not change conditions in a manner that will substantially modify the environmental baseline conditions of the distribution or abundance of predatory piscivorous fish in the CRS reservoirs; thus, outmigrating UCR spring-run Chinook salmon are anticipated to continue to be exposed to predation as they migrate through the CRS. Fish in the tailraces may be particularly susceptible to predation based on their passage route through the dam, due to potential disorientation from the passage experience. However, the flex spill program may help reduce baseline predation conditions in CRS dam tailraces by increasing the turbulence in the immediate downstream vicinity of the dams, making it more difficult for birds to locate and prey upon juvenile salmonids in these areas. As described above, lower turbidity levels throughout the mainstem Columbia and Snake Rivers caused by the existence of dams may influence the effectiveness of visual predators.

Efforts to minimize predation by birds and fish will continue with the Proposed Action. In 1990, the Action Agencies began a program to reduce predation by northern pikeminnow by removal at the dams and a sport reward program that pays anglers for pikeminnow removed (see NPMP below). 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. Avian dissuasion

actions at the dams (e.g., wires, sprinklers, etc.) will also continue with implementation of the Proposed Action. Collectively, these efforts are intended to continue to minimize predation rates on outmigrating juvenile UCR spring-run Chinook salmon through the CRS.

Non-Operational

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs and there are currently four fall Chinook hatchery programs in the Snake River Basin. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to operation of federal and non-federal dams, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin Chinook salmon and their habitat depends on the design of hatchery programs (which have existing consultation), the condition of the habitat, and the status of the species, among other factors.

The majority of hatchery programs are run by the state in which they occur or tribes. It is anticipated that most of the current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue. Current hatchery programs will continue to be studied and management agencies will make recommendations to reduce potential effects if they occur.

Predation Management

Predation on salmon and spring-run Chinook salmon in the Columbia River Basin affects survival and viability. Birds and native and non-native fish prey on juveniles as they pass through the hydrosystem. Direct predation occurs when hatchery-origin fish eat natural-origin fish; indirect predation occurs when predation from other sources increases as a result of the added abundance of juvenile salmon and spring-run Chinook salmon from hatchery releases. In addition, there are some project-specific effects to UCR Chinook as a result of implementing some components of predator management that will be discussed below.

Avian

Bird predation is a significant environmental baseline source of mortality for UCR spring-run Chinook salmon (Evans et al. 2018). The Action Agencies have developed various plans to help minimize predation by birds. In 2014, the IAPMP began (Corps 2014a). This plan manages avian predation on juvenile salmonids as they migrate to the ocean by reducing bird nesting colonies in inland areas by installing a variety of passive nest dissuasion materials prior to nesting seasons (Evans et al. 2018).

Prior to the IAPMP, tern predation on UCR spring-run Chinook averaged 2.5 percent from the colony located at Goose Island, which is on Potholes Reservoir. After management activities began in 2014, predation on UCR spring-run Chinook salmon was reduced to less than 0.1 percent from 2014–2018, and there have been no colonies nesting on Goose Island since 2015 (Collis et al. 2019). While the most significant tern predation of UCR spring-run Chinook salmon historically occurred from the Goose Island colony, other colonies have also impacted UCR spring-run Chinook salmon. For example, Crescent Island, which is in the McNary Reservoir, has had similar results from the ISPMP, where prior to management

activities, predation on UCR spring-run Chinook salmon averaged 0.53 percent, and there have not been any colonies nesting there since 2014.

Continued implementation of this plan in the Proposed Action will continue to minimize predation from birds on juvenile salmonids, including UCR spring-run Chinook salmon, migrating through the CRS.

Piscivorous Fish

The northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River. In 1990, the Action Agencies began The NPMP to reduce predation by northern pikeminnow by removing fish at the dams, and a sport reward program that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake Rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. Juvenile UCR salmon may be impacted during collection of pikeminnow for tagging associated with the sport reward program (Williams et al. 2017).

All predator management programs will continue under the Proposed Action and will continue to reduce the consumption of juvenile salmon and spring-run Chinook salmon. Incidental catch of ESA-listed salmon and steelhead as a result of implementing the Pikeminnow Sport Reward Fishery and dam angling program has occurred in the past and is likely to continue at a similar rate in the future. While the numbers are low (NMFS estimated that no more than ten adults and 20 juvenile Chinook would be caught), some individuals are likely part of the UCR steelhead DPS.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on UCR spring-run Chinook salmon. These are associated with the capturing and handling of fish at CRS dams. Research, monitoring, and evaluation activities occur throughout the Columbia River Basin as part of managing the CRS. In general, the RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness monitoring and research, critical uncertainty research, and data management. Capturing, handling, marking/tagging, and releasing fish generally leads to stress and other sub-lethal effects, but fish sometimes die from such treatment. Some RM&E actions also involve sacrificial sampling of fish. (2019) estimated the number of juvenile UCR spring-run Chinook salmon that have been handled each year during the implementation of RM&E under the 2008 BiOp and determined that the average handling and mortality were not substantial. They concluded that

... slightly more than one percent of the wild juvenile production was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to one percent of these juveniles (in this case, <0.02 percent of the wild production) died after they were released due to effects of handling. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of FCRPS operations, including modifications to facilities, operations, and mitigation actions.

It is reasonable to assume that implementing the Proposed Action will result in the number of individual UCR spring-run Chinook salmon handled, injured, and/or killed from RM&E activities at CRS dams will continue at approximately the same level in the future.

Juvenile UCR Spring-run Chinook salmon Estuary Migration and Rearing, Including the Plume

Estuarine and nearshore ecosystems provide habitat for juvenile spring-run Chinook salmon to forage and avoid predators. Most juvenile spring-run Chinook salmon move through the estuary quickly, and survival in this reach appears to be high (Jacobson et al. 2012).

The existence and operations of the CRS has led to long-standing changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, the effects of CRS water management in the estuary are generally attenuated by the distance from the facilities and inflow from tributaries like the Willamette and Cowlitz Rivers. Thus, any direct impacts from flow or elevated TDG in this area are expected to be minor.

In addition, there is an apparent relationship between plume characteristics at time of ocean entry and SARs for spring-run Chinook salmon. Jacobson et al. (2012) found that spring-run Chinook salmon SARs increased with the size and offshore distance of the plume under favorable large-scale ocean conditions, but did not change when ocean conditions were poor (Jacobson et al. 2012).

Avian predation continues to be a serious issue in the estuary. Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary will benefit this ESU by reducing the number of individuals of this ESU eaten by birds in the estuary (e.g., see Figures 50 and 52, Corps et al. 2017, Section 1).

Below is a more detailed analysis of the effects of the Proposed Action on UCR spring-run Chinook salmon.

Operational

Survival

Fish use in the estuary likely influences their subsequent survival in the ocean. Monitoring and research suggests that fish size and time of ocean entry, which are in part due to conditions in the estuary, can affect salmon growth and survival in the ocean (Chittaro et al. 2018; Johnson et al. 2018). Habitat enhancements that improve capacity (e.g., prey productivity) may lead to increased growth and improved condition of migrating juvenile salmonids as they forage in the estuary. The improved condition of fish in the estuary can contribute to increasing the likelihood of their survival into the ocean.

Fish Travel Time

Proposed changes in water management are not expected to increase flows downstream of Bonneville Dam and, therefore, the factors that currently influence fish travel time through the estuary are not likely to change. The travel time of juvenile UCR spring-run Chinook salmon that pass Bonneville Dam is not likely to change from the current condition under the Proposed Action.

TDG Levels

As mentioned previously, GBT was historically a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019). Elevated TDG levels and associated effects from GBT occur during periods of increased spill downstream until they are attenuated at approximately RM 110 (NMFS 2019); juvenile UCR spring Chinook exposed to increased TDG levels (120% to 125%) are likely to experience slight increases of GBT compared to baseline conditions.

Temperature Changes

As mentioned above, during the time when juvenile UCR Chinook are outmigrating, the proposed operation of the CRS has limited capabilities to modify water temperatures in the mainstem Snake and Columbia Rivers. Therefore, water temperature changes are not expected under the Proposed Action upstream of Bonneville Dam, nor are they anticipated for the Columbia River reach downstream from Bonneville Dam.

Turbidity

As mentioned previously, baseline turbidity is modified from historic conditions, and it is not anticipated that implementing the Proposed Action will affect existing turbidity conditions in the CRS, including the section downstream from Bonneville Dam.

Predation Rates

Based on PIT-tag recoveries at East Sand Island (near the mouth of the Columbia River), average annual tern predation rates on UCR spring-run Chinook salmon were 3.9 percent before efforts to manage the size and nesting location of these colonies (Evans et al. 2018). Previous management actions implemented by the Action Agencies to relocate various colonies has had some positive effect by reducing the predation rate on UCR spring-run Chinook salmon to 1.6 percent (Evans et al. 2018).

The Action Agencies have developed various plans to help minimize bird predation (Corps 2013a, 2015b). These plans manage avian predation on juvenile salmonids in the Columbia River Estuary by redistributing bird nesting colonies to other nesting sites in the western U.S. The Action Agencies will continue implementing these plans to continue to minimize predation from birds on juvenile salmonids, including UCR spring-run Chinook salmon.

The predator management programs are intended to maintain these reductions in predation on juvenile salmonids in the Columbia River estuary. Continued implementation of the Caspian tern and cormorant management programs, and the NPMP will continue to minimize predation on juvenile salmon and steelhead, including UCR Chinook salmon.

Non-Operational

Predation Monitoring

The Proposed Action will continue to implement the various predator management programs and their monitoring components that are currently being implemented in the estuary and mainstem Columbia River. Some ESA-listed salmon and steelhead are captured as part of implementing the Pikeminnow Sport Reward Fishery and dam angling program (below Bonneville). The number of individual UCR spring Chinook impacted is likely to continue at a similar rate in the future. While the numbers are low across the entire program (NMFS estimated that no more than ten adults and 20 juvenile Chinook would be caught), some individuals encountered below Bonneville Dam may be captured, injured, or killed.

Estuary Habitat Actions

As part of the Proposed Action, the Action Agencies will continue implementing the CEERP to improve estuarine habitat and tidally-influenced portions of tributaries used by anadromous salmon and steelhead. The planned improvements in habitat functions are expected to provide long-term benefits to native species that use these habitats, through improved ecological function and process. Appropriate ESA consultation is typically undertaken prior to implementation of these projects at site-specific scale. These ESA consultations are complete with incidental take statements (ITSS) and implanting Terms and Conditions with which the Action Agencies comply.

Fish Status and Trend Monitoring

One aspect of the CEERP is to monitor the effectiveness of restoration actions and conduct research to address critical uncertainties. Adaptive management is used to guide program goals and actions (Johnson et al. 2018), and research, monitoring, and evaluation will continue under the Proposed Action. As illustrated above, the CEERP is benefitting salmonids, both in the juvenile and adult life-history stages.

Ocean Rearing

CRS management has no direct influence on survival of UCR spring Chinook in the Pacific Ocean. There are, however, a small number of individual salmon and steelhead that could experience deleterious direct effects from capture and handling from a Bonneville-funded study of juvenile salmonid ecology in the plume and nearshore ocean. Indirect effects on survival of UCR steelhead from CRS management include any latent/delayed mortality manifested in the ocean and the positive influence CRS management can have on juvenile migration and growth in the estuary, which is related to improved survival during early ocean entry.

The Proposed Action will have no effect on the ocean habitats used by UCR spring Chinook for growth and maturing because there are no CRS operations that affect this area (the Columbia River plume was addressed above).

Adult UCR Spring-run Chinook Migration to Bonneville Dam

While no indices of migration rate from coastal waters to Bonneville Dam exist for UCR spring Chinook, NMFS reported that SR spring/summer Chinook took on average 18.1 days in 2011 and 15.4 days in 2012 to navigate that reach of river (NMFS 2014a). Adult UCR spring Chinook enter the Columbia River in April and May, with the peak around mid-May. It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River by the distance from the facilities and the streamflows from lower river tributaries like the Willamette River. The Proposed Action is unlikely to cause adult migration barriers for UCR spring Chinook adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. Pinniped management actions at Bonneville Dam are expected to reduce this impact to some degree. Thus, overall, the Proposed Action is likely to have negligible effects on UCR spring Chinook adult migration from the ocean to the CRS.

A more detailed analysis of effects to adult UCR spring Chinook returning to the Columbia River and migrating up to the system as a result of implementing the Proposed Action is described below.

Operational

Travel Time

The Proposed Action is not expected to negatively affect the migration rate of adult UCR spring Chinook in the lower Columbia River downstream from Bonneville Dam. The Proposed Action will result in negligible flow reductions, and thus a minor reduction in water particle velocity at the time adult spring Chinook will be entering and migrating through the lower Columbia River. Therefore, the Proposed Action is not expected to result in a measurable increase or decrease in migration rate.

Total Dissolved Gas

The Proposed Action includes a flexible spill component, which during spring spill operations will result in spill at CRS projects to a level where the state water quality limit (125%) for TDG is met 16 hours per day, with a performance standard spill component totaling 8 hours per day. As such, TDG levels will reach 125 percent of saturation during the 16-hour block, and a lesser amount during the performance spill component. The flex spill program will occur April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects. Based on these operations, it is anticipated that some migrating adult UCR spring Chinook will be exposed to slightly elevated TDG levels downstream from Bonneville Dam.

As discussed earlier, elevated levels of TDG can increase the likelihood of GBT in adult and juvenile salmonids, which can injure or kill afflicted individuals. To offset the extent of gas supersaturation at CRS projects, the COE has installed gas abatement devices within the spillways to reduce TDG levels.

Severe GBT is not typically observed when TDG levels do not exceed 120 percent. Furthermore, GBT in juvenile salmonids remains below 2 percent when TDG levels do not exceed 120 percent, and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). In 2019, the Action Agencies operated spill at CRS projects to reach but not exceed 120 percent TDG. At those levels, reach survival and observed GBT did not reach measurable levels (NMFS 2019).

Based on the attenuating effect of the distance downstream of the system and the influence of tributary streamflow, effects of the Proposed Action are not expected to have measurable effects on UCR spring Chinook adults downstream from Bonneville Dam.

Temperature

Poor water quality, which includes increased water temperature, can lead to stress in adult UCR spring Chinook, which in turn can lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth and osmoregulation). Furthermore, elevated water temperatures can affect salmonid distribution, behavior, migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult UCR spring Chinook (NMFS 2019).

Because actions associated with the Proposed Action will not result in elevated water temperatures downstream from Bonneville Dam, effects of the Proposed Action are not expected to negatively impact adult UCR spring Chinook within this reach.

Turbidity

Existence of the hydroelectric system has altered the extent of sediment transport downstream through the Columbia River, including the reach downstream from Bonneville Dam. It is estimated that the total sediment discharge into the estuary and the Columbia River plume is approximately one-third of pre-hydrosystem levels, which has altered the development of habitats along the margins of the river (NMFS 2019).

Because actions associated with the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam, the Proposed Action is not expected to negatively impact adult UCR spring Chinook within this reach.

Non-Operational

Predation

For upstream migrating adult UCR spring-run Chinook salmon, the primary factor affecting survival through the estuary to Bonneville Dam is likely pinniped predation. The existence of Bonneville Dam, which is part of the environmental baseline, likely causes pinnipeds to congregate downstream from that project. However, if Bonneville Dam were not present, the pinnipeds would likely congregate at Cascade Falls or other upstream falls, much like they do at Willamette Falls.

As noted by UCSRB (2019), NOAA fisheries modeling of pinniped predation has shown a trend of decreased survival for studied spring Chinook populations. The earliest arriving spring Chinook in recent years experienced the greatest pinniped caused mortality, including Methow River spring-run Chinook

(22 percent mortality) compared to intermediate arriving populations like the Entiat and Wenatchee River spring Chinook (11 percent) relative to late-arriving populations (UCSRB 2019). For the early-arriving Methow River spring Chinook, an estimated 35 percent of the returning adult population was lost to predation between the estuary and Bonneville Dam in 2015 [Sorel et al. (2017) as cited in UCSRB (2019)]. Predation rates have declined over the last 2 years. Pinniped injury rates noted at Bonneville Dam for spring Chinook and steelhead have varied from 11 to 37 percent [1999–2005; Scordino (2010); as cited in UCSRB (2019)].

Measures intended to reduce the baseline condition of pinniped predation on adult salmonids such as hazing, removal, and the continued use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates) will continue under the Proposed Action. Furthermore, if pinnipeds are observed in the tailrace of The Dalles Dam, hazing efforts may be implemented at that project's ladder entrances. No components of the Proposed action are expected to result in a change from current conditions associated with pinniped predation.

Adult UCR Spring-run Chinook Migration Through CRS Dams

Adult UCR spring-run Chinook use fish ladders to swim past four Lower Columbia River CRS dams on their way to the spawning grounds. Fish returning to the Wenatchee River Basin must pass seven mainstem hydroelectric projects (the four lower Columbia River CRS projects and three PUD dams), while fish entering the Entiat River pass eight dams, and those migrating to the Methow River pass nine dams.

Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life-stages such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

As reported earlier, after accounting for reported harvest rates and expected stray rates, adult UCR spring-run Chinook typically have relatively high survival rates passing the four lower CRS dams as well as through hydroelectric projects owned and operated by Grant, Chelan, and Douglas PUDs (NMFS 2019).

Based on conversion rates of PIT-tagged UCR spring-run Chinook salmon detected at Bonneville Dam for the years of 2008 to 2017, the minimum estimate of survival for the Bonneville to McNary reach averaged 91.5 percent over the 10-year period (range of 80.4 to 105.1 percent). This estimate of minimum survival includes all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 97.1 percent per project (NMFS 2019). These estimates of minimum survival also account for impacts associated with fallback at the lower CRS projects, such as direct and indirect mortality associated with the fallback event, delay, straying, etc.

Based on the same dataset, the minimum survival estimate for the McNary to Priest Rapids reach has been estimated to be 94.7 percent (range of 91.2 to 97.9 percent) and the McNary to Wells Dam reach 90.2 percent (range of 85.4 to 96.3 percent). A comparison of survival rates for the McNary to Priest Rapids and McNary to Wells reaches yields an average minimum survival rate of 95.4 percent for the Priest Rapids to Wells reach, with a per-project survival estimate of 98.8 percent (NMFS 2019). Based on the relatively high survival estimates, NMFS noted that upstream passage conditions for adult UCR

spring-run Chinook salmon are not substantially impaired as fish migrate through impounded reaches of the lower and middle Columbia River.

A more detailed analysis of effects to adult UCR spring Chinook migrating upstream through the CRS as a result of implementing the Proposed Action is described below.

Operational

As discussed previously, the Proposed Action includes a flexible spill component, which during spring spill operations will result in spill at CRS projects to a level where the state water quality limit for TDG is met 16 hours per day, with a performance spill component totaling 8 hours per day. As such, TDG levels will reach 125 percent of saturation during the 16-hour block, and a lesser amount during the performance standard spill component. Performance spill standards vary by project but are based either on a volume of water passing via the spillway (i.e., kcfs), or the proportion of the overall river flow that is spilled. The flex spill program will occur April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects. The NWFSC LCM, comparing MO4 to the NAA 2016 operations, indicated a two percent increase in SARs and an average 6% increase in abundance of adult returns to spawning grounds (Table 3-40).

Other components of the Proposed Action include structural measures such as modifying the Bonneville ladder serpentine weir (to reduce delay within the fishway), and the flexibility to increase the reservoir drawdown within the John Day reservoir by 0.5 feet. Collectively, these measures have the potential to impact UCR spring Chinook.

Table 3-40. Adult model metrics for UCR spring-run Chinook salmon

Metric (Model)	NAA 2016 Ops	MO1 Performance Standard Spill	MO4 Upper Range	Range	% Change between low and high
Rock Island to Bonneville SARs (NWFSC LCM)	0.94%	0.95%	0.96%	0.2%	2.1%
Abundance of Wenatchee population, representative of the UCR spring-run Chinook Salmon ESU. NWFSC LCM abundance range with decreased latent mortality (number of adults) ¹⁹	498	526 (0%) 570 (10%) 690 (25%) 822 (50%)	513 (0%) 673 (10%) 901 (25%) 1,308 (50%)	28 (0%) 175 (10%) 403 (25%) 810 (50%)	6% (0%) 35% (10%) 81% (25%) 163% (50%)

Total Dissolved Gas

Populations of adult UCR spring Chinook enter the Columbia River estuary and pass over Bonneville Dam beginning in April and continue through the end of May, with the peak around mid-May (NMFS 2019). Because of the increased TDG levels associated with the flex spill component of the Proposed Action, most if not all of the migrating adult UCR spring Chinook within the CRS will likely be exposed to elevated TDG levels.

As described in the previous section, GBT is not typically observed when TDG levels do not exceed 120 percent, and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Based on the limited observations of GBT at expected TDG levels associated with the Proposed Action and given the migration timing of adult UCR spring Chinook within the CRS, the Proposed Action is not expected to result in an elevated risk of GBT to UCR spring Chinook. Elevated TDG levels are not expected to be encountered after fish pass upstream of the Snake River confluence.

Fallback

Adult UCR spring Chinook can fallback at dams while migrating upstream to their natal streams. Typical fallback occurs after an individual ascends a fishway and then passes back downstream from the project in a relatively short period of time. This activity is often associated with higher spill levels at the project. Based on data for the years of 2005 to 2014 (except at The Dalles where only two years of data are available: 2013 and 2014), mean annual fallback rates for adult UCR spring-run Chinook were 9.8, 1.0, and 9.4 percent at Bonneville, The Dalles, and McNary dams, respectively. In the UCR, fallback rates were 1.5 percent at Priest Rapids Dam and 5.6 percent at Rock Island Dam (Crozier et al. 2016).

¹⁹ NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARs or abundance output. For discussion purposes, potential increases in ocean survival of 10%, 25%, and 50% are shown. The value for 0% is the actual model output, the 10%, 25%, and 50% values represent scenarios of what SARs or abundance hypothetically could be under the increased ocean survival if changes in the alternative were to decrease latent mortality by that much.

The Proposed Action, specifically the flex spill component, will have the potential to increase the rate of fallback at CRS dams. With increased spill, it is likely more of the fish that fallback at a given project will do so through the spillway, or some surface-oriented passage route. For fish that do fallback during the flex spill program, and specifically through the spillway or a surface structure, survival of that fallback event is likely relatively high. At Bonneville Dam, direct survival tests using rainbow trout as a surrogate for steelhead kelts revealed that for fish passing downstream of the dam via the Ice/Trash sluiceway and the corner collector, survival was greater than 98 percent (after 48 hours). At McNary, direct survival was estimated to be approximately 98 percent for hatchery steelhead through the TSW. Conversely, direct survival through the McNary turbines was estimated to be approximately 91 percent (Keefer et al. 2016). While the investigations of direct survival relied on surrogate species, it is likely similar results would apply to UCR spring Chinook.

Temperature

As described previously, poor water quality, which includes increased water temperature, can lead to stress in adult UCR spring Chinook, which in turn can lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth and osmoregulation). Furthermore, elevated water temperatures can affect salmonid distribution, behavior, migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult UCR spring Chinook (NMFS 2019).

Major factors that influence water temperatures within the Columbia River Basin include natural variations in weather and river flow; the existence of the hydroelectric system; increased tributary temperatures due to irrigation, grazing, and logging; urbanization and population growth; and projected increased air temperature due to climate change. The extent that these variables influence water temperatures within the CRS is expected to increase as urbanization and population growth increase, and the effects of climate change become more pronounced. However, implementation of the Proposed Action is not expected to alter water temperatures within the CRS.

Because actions associated with the Proposed Action will not result in elevated water temperatures within the CRS, effects of the Proposed Action are not expected to affect adult UCR spring Chinook within this reach.

Turbidity

Development of the hydroelectric system has altered the extent of sediment transport downstream through the Columbia River, including within the CRS. While other anthropogenic activities such as agriculture, irrigation, mining, logging, road building, etc., have increased sediment into the mainstem Columbia River, both federal and non-federal dams act as a sediment sink, trapping sediments upstream from dams. These activities and baseline conditions are expected to continue at the current rate.

Because actions associated with the Proposed Action are not expected to result in changes in baseline sediment load within the CRS, the Proposed Action is not expected to affect adult UCR spring Chinook within this reach.

Non-Operational

Predation

Predation on adult UCR spring Chinook within the CRS is rare, with pinnipeds being the primary predator. While pinniped predation commonly occurs within the tailrace of Bonneville Dam downstream to the Pacific Ocean, pinniped observations upstream from Bonneville Dam are rare, with no observation above the Dalles Dam.

Measures intended to reduce predation on adult salmonids such as hazing, removal, and use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates) will continue. Furthermore, if pinnipeds are observed in the tailrace of The Dalles Dam, hazing efforts may be implemented at that project's ladder entrances. No components of the Proposed action are expected to result in a change associated with pinniped predation.

Adult UCR Spring Chinook Migration Upstream of the CRS to the Spawning Areas

Operational

After migrating upstream through the CRS, adult UCR spring Chinook begin to migrate to their natal streams. Along the way they must pass a number of non-federal dams. For the most part, exposures to the majority of CRS-related water quality and quantity aspects of the Proposed Action are reduced dramatically after passing the Snake River confluence; though some influence from upper mainstem dams and other upriver CRS projects is still occurring. Once they enter their natal tributaries, they are no longer exposed to the operation and related effects of the CRS.

As described previously, within the UCR tributaries that support the spawning and rearing of UCR spring Chinook populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (1) impaired fish passage (including tributary dams); (2) reduced stream complexity and channel structure; (3) an excess of fine sediments; (4) elevated summer water temperature; (5) diminished streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019). All of which are outside the scope of the operation and maintenance of the CRS.

Non-operational

Within UCR spring Chinook tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this ESU. The following provides a more detailed description of the effects of those actions.

Hatchery Programs

The hatchery programs described above will be implemented into the future without alteration under the Proposed Action. As such, no change in UCR spring Chinook is anticipated due to hatchery operations.

Tributary Habitat Actions

Nearly all of the historical habitat for UCR spring Chinook has been extensively modified through anthropogenic actions. As described previously, many factors limit the viability of this ESU. In response, many habitat measures have been implemented specifically to benefit UCR spring Chinook by federal, state, local, and private entities, including the Action Agencies. Based on the best available science, NMFS concluded that these actions have, and will continue to improve habitat for UCR spring Chinook as these projects mature. Furthermore, fish population abundance, productivity, spatial structure, and diversity should respond positively (NMFS 2019) to these improvements to baseline conditions.

Fish Status and Trend Monitoring

It is anticipated that the Action Agencies' RM&E program will continue at current levels of effort, or perhaps at somewhat reduced levels. As such, the level of injury and mortality associated primarily with the capture, handling, and marking/tagging of UCR spring Chinook is expected to be maintained at current or slightly decreased levels.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Effects of the Proposed Action on critical habitat are discussed in this section. Effects to critical habitat were assessed based on those elements of the Proposed Action that are likely to affect the physical and biological features (PBFs) essential for the conservation of the UCR spring-run Chinook ESU. Effects to designated critical habitat include the Proposed Action and associated mitigation that affect habitat within tributary spawning and rearing areas, the freshwater migration corridor, and estuarine areas.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of UCR spring-run Chinook salmon. Freshwater spawning and rearing areas occur upstream of the CRS so the effects of the Proposed Action are limited to tributary habitat mitigation actions that are intended to improve habitat function for UCR spring-run Chinook salmon. For the tributary habitat program there will be some uncertainty about the actual locations, extent, and types of tributary habitat actions that will be implemented as part of the Proposed Action. However, anticipated effects of the tributary habitat improvement program are expected to include short-term and will be mitigated through compliance with BiOp on Columbia River habitat improvements (NMFS 2013), temporary impacts associated with stream restoration activities and long-term positive effects associated with the tributary habitat program. Effects to critical habitat within the upper Columbia ESU from the Winthrop spring Chinook salmon NFH are considered part of the baseline because these programs have undergone separate, program specific ESA consultation with (NMFS 2019).

Freshwater Migration Corridors

Freshwater migration corridors are used by returning adult spring-run Chinook salmon migrating upstream through the CRS and by juveniles migrating downstream past Bonneville Dam. The four lower CRS dams and reservoirs have and will continue to affect the function of critical habitat within the mainstem Columbia River, which continues to influence passage and survival of juvenile and adult migrants and is part of the baseline conditions. The Proposed Action includes ongoing actions to maintain or improve the freshwater migratory PBFs through operation and maintenance of passage improvements through the system and implementation of the predator management programs, which are intended to reduce the consumption of juvenile and adult salmon within the CRS. These programs are intended to improve downstream survival and will continue to reduce the risk of predation on UCR spring-run Chinook salmon.

The Proposed Action also includes both structural and operational modifications to the CRS that will affect water quality and passage PBFs that UCR spring-run Chinook salmon must migrate through to complete their life cycle. The overall effects to the PBFs of the Proposed Action are slightly positive with respect to passage conditions and risk of predation and slightly negative relative to elevated TDG. Continued effects to stream temperature, sediment, and turbidity are anticipated with the CRS but effects to these water quality PBF indicators are likely to remain unchanged as a result of the Proposed Action. Passage conditions at each of the projects are anticipated to improve for juvenile Chinook salmon as the flex spill program will provide more advantageous passage routes through spill bays at each of the projects. Increasing the proportion of water discharged through the spill bays at each of the dams will reduce forebay residence time by providing a more pronounced surface-oriented flow path for juvenile Chinook salmon, which it is hypothesized will reduce latent mortality.

Estuarine and Nearshore Marine Areas

Estuary and nearshore ocean areas have been designated as essential for the conservation of UCR spring-run Chinook. Ongoing implementation of the CEERP and predator removal and harassment programs is anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of the CEERP is likely to increase the capacity and quality of habitat in the estuary while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal and harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to improve the safe passage feature of critical habitat.

The Proposed Action includes operational modifications to the CRS that may affect water quality habitat features downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions with a slight but potential increase in TDG associated with the flex spill program. The highest TDG levels (125%) are expected in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). Continued effects to the PBFs associated with stream temperature, sediment, and turbidity are anticipated downstream from the CRS but are likely to remain unchanged as a result of the Proposed Action. Current passage habitat features will be

unaffected for juvenile and adult UCR spring-run Chinook as they migrate through the Columbia River estuary and into nearshore ocean.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on UCR spring-run Chinook in the context of the environmental baseline and cumulative effects. Cumulative effects are effects of future state or private activities that are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline condition (whether they are federal, state, or private). To the extent those same activities are reasonably certain to occur in the future (and are state or private), their future effects are included in the cumulative effects analyses.

Most of the action, baseline, and cumulative effects identified in the analysis above are consistent with effects previously described for operation of the CRS in past consultations. In general, the Proposed Action as a whole is not likely to limit species survival or critical habitat function. It carries forward a suite of beneficial actions that improve baseline conditions and offset negative effects attributable to the regulation of flows, including flow augmentation, fish passage operations, predation management, and habitat improvement. Though the Proposed Action does not cause substantial changes to current species conditions, there may be some modest site-specific effects from the continued operation of the CRS. It is also possible that increased spill levels, and associated adverse effects, will be offset by an increase in adult returns due to less powerhouse encounters as hypothesized by the CSS.

The summary below will follow the general structure of the analysis above and will discuss each factor that was previously evaluated.

Operational

Survival

Survival of juvenile UCR spring-run Chinook salmon through the CRS is affected by the number of dams they pass, predators, travel time, and water quality. These factors are the result of multiple influences, including past the existence and continued operation of the CRS. Survival has improved for juvenile UCR spring-run Chinook salmon migrating through the CRS to the ocean as a result of past actions. Juvenile Chinook salmon survival has also improved in the estuary and tributaries due to habitat improvements implemented by the Action Agencies. For adult UCR spring-run Chinook salmon, survival has been and will likely continue to be affected in the estuary up to Bonneville Dam by pinniped predators.

Future non-federal actions, and the effects of climate change and variable ocean conditions, have the potential to affect survival of UCR spring-run Chinook salmon. Land use activities (primarily non-federal) have the potential to affect juvenile survival by decreasing tributary and estuary habitat or degrading abiotic factors, such as stream temperature from urban, rural, and agricultural development and runoff. Further degradation of tributary habitat could also affect adult UCR spring-run Chinook salmon survival by reducing holding and spawning areas, or development of passage barriers. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies implement fisheries

that can have a direct effect on the number of returning spring-run Chinook salmon to the UCR tributaries (and in some cases, within the tributaries themselves).

It is anticipated that survival gains resulting from previous actions will continue and possibly increase by continuing tributary and estuary habitat actions as well as improvements to juvenile and adult passage conditions at the CRS dams. It is also anticipated that improvement to juvenile and adult passage conditions at the CRS dams will be maintained. For downstream migrating juveniles, it is anticipated that not only will survival through the CRS improve, but ocean survival may increase as a result of fish entering the ocean with fewer powerhouse encounters during their downstream migration, should the latent mortality hypothesis be valid. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications to actions.

Fish Travel Time

The existence and on-going operation of the CRS has slowed juvenile travel time compared to the pre-CRS condition, potentially increasing exposure to predators as they migrate through the CRS. Travel time within the tributaries and estuary are not affected by the existence or operation of the CRS. While travel time of UCR juveniles within the CRS varies from year to year, actions from the past that are on-going, send more fish through non-turbine routes, which is believed to decrease travel time and improve survival. Adult travel time is not considered an issue, although increased water temperatures may lead to migrational delays.

Future non-federal actions are not expected to affect the travel time of juveniles or adults through the CRS during any life stage. However, it is anticipated that projected increased air temperature due to climate change will continue to increase overall temperatures in the Columbia River, and therefore have the potential to further affect adult UCR spring-run Chinook's upstream migrational timing, and possibly juvenile emigration timing.

The Proposed Action is anticipated to reduce forebay residence time (a decrease in downstream travel time) for juvenile UCR spring-run Chinook salmon migrating past CRS during the flexible spill implementation. Continued monitoring of adult UCR spring-run Chinook salmon migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse Passage Proportion

Past and current physical modifications and operations of the CRS has increased the percentage of juvenile fish passing non-turbine routes. Decreasing powerhouse passage improves survival of juveniles during their downstream migration.

The Proposed Action will continue operations and actions that have resulted in increased non-turbine passage at the CRS projects. The Proposed Action will increase spill during the juvenile migration period and that is expected to result in fewer powerhouse encounters for juvenile UCR spring run Chinook during their downstream migration. It is hypothesized that the fewer powerhouse encounters outmigrating juvenile salmon and steelhead experience, the greater likelihood of survival during their

ocean life stage, and subsequently the greater returns of adult fish. In addition, as techniques and additional operations are considered, further increases in non-turbine passage could occur.

Water Quality

Total Dissolved Gas

TDG has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high rates that resulted in GBT in juveniles and adults as they migrated through the CRS. Elevated TDG levels are not observed within tributaries or the estuary (where the effects of CRS operations on TDG are attenuated by distance and tributary inflow). The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

It is anticipated that implementing the flexible spill program will elevate TDG levels that may slightly increase the incidence of GBT in juvenile fish.

Temperature Changes

Water temperatures have been modified as a result of a range of anthropogenic activities, including the existence and on-going operation of the CRS, throughout the Columbia Basin. Increases in temperature can have a range of effects on both juvenile and adult UCR spring-run Chinook salmon.

On-going non-federal land management activities that affect stream temperatures, such as agriculture and urbanization and forestry, are not expected to improve substantially during the period of this consultation. However, small improvements may be realized from tributary actions that restore and preserve habitat, like riparian plantings.

Implementation of the Proposed Action will continue to modestly improve tributary temperatures but will continue to have minimal effect on mainstem temperatures during the time when UCR Chinook are migrating (up or down) through the CRS.

Turbidity Levels

Currently, sediment loads in tributaries have been affected by historic land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and rearing habitat. In the mainstem Columbia River, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk.

In the tributaries, non-federal actions, such as urban., rural, and agricultural development are likely to continue to affect turbidity; however, improvements in tributary habitat included in the Proposed Action are expected to result in reduced sediment inputs, resulting in modest, site specific improvements that will mitigate continued non-CRS activities that degrade habitat. In the mainstem Columbia River, the current condition is not anticipated to change, and no non-federal activities are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment delivery levels from the tributaries. On the mainstem Columbia River, it is not anticipated that the Proposed Action will change the current condition.

Dam Passage (adults)

Currently, UCR spring-run Chinook salmon migrate upstream through four lower CRS projects on their way to natal spawning areas and experience a variety of factors affecting them, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish. Current adult passage conditions should continue with a slight modification of the upper serpentine flow control ladder section at Bonneville Dam, which should improve fish passage by helping reduce delay. UCR spring-run Chinook salmon appear to survive their migration through the CRS at high levels and those survival rates are expected to continue with implementation of the Proposed Action.

Non-federal actions that have the potential to directly affect UCR spring-run Chinook adults migrating through the CRS are unlikely. However, the continued degradation of tributary habitat, which increases temperatures, and projected increased air temperature due to climate change, which results in warming surface water temperatures, indirectly influence migratory behavior in ways that slow or delay upstream migration and reduce survival and reproduction.

The Proposed Action will continue to monitor adult migration through the CRS and use that information to propose specific actions that will increase adult survival.

Non-operational

Predation

Currently, both juvenile and adult UCR spring-run Chinook salmon encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinnipeds prey on adults as they enter the Columbia River from the ocean to the tailrace of Bonneville Dam, often leading to the mortality of a significant portion of the returning UCR adults. A variety of native and non-native fish and birds also prey on juveniles as they pass through the CRS, mostly in the tailraces of dams. This predation accounts for a portion of juvenile mortality during migration through the CRS.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS operations have no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

The Proposed Action will continue to implement the predator management programs to limit UCR Chinook mortality from environmental baseline conditions. This should ensure that predation caused mortality does not increase, and may reduce overall predation rates. Some impacts to UCR Chinook will occur as a result of implementing the northern pikeminnow predation program, but is considered minor.

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to the operation of hydro facilities, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin salmon and steelhead and their habitat depends on the design of hatchery programs, the condition of the habitat, and the status of the species, among other factors.

The majority of hatchery programs are run by the state in which they occur. It is anticipated that most of the current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue.

The Proposed Action will continue to fund and monitor conservation and safety-net hatchery programs that mitigate for the CRS operations. The potential deleterious effects of hatchery-origin fish on natural-origin fish will continue to be studied and management agencies will make recommendations to reduce those potential effects.

Habitat Actions

Habitat conditions in the tributaries, mainstem Columbia River, and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect UCR spring-run Chinook include continued degradation of tributary habitat that increases stream temperatures and projected increased air temperature due to climate change that will likely warm surface water temperatures.

The Proposed Action will continue to rehabilitate the degraded baseline conditions of habitat in the tributaries and estuary and thereby improve long-term survival of UCR spring-run Chinook.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on UCR spring-run Chinook salmon. These are associated with the capturing and handling of fish. Research, monitoring, and evaluation activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no non-federal actions anticipated that would affect RM&E activities.

The Proposed Action will continue to implement the RM&E programs that are currently occurring, with the potential to modify these programs in the future as the results of the monitoring programs are evaluated. The NMFS has not identified RM&E activities as a substantial impact to UCR spring Chinook.

Summary

In Table 3-41, the Proposed Action is compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action.

Most of the actions are anticipated to either have no effect, or a positive effect compared to the baseline condition (Table 3-41). This is partly because the Proposed Action continues numerous beneficial actions developed over the preceding decade, including habitat improvement, flow augmentation, and fish passage operations. Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-41. Summary comparison of the Proposed Action to current conditions for UCR spring-run Chinook salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Juvenile Spring-run Chinook salmon Downstream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival.
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x		+	Continuation of predator management programs should decrease predation.
	Hatcheries	x		=	
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Juvenile Spring-run Chinook salmon Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
Turbidity levels	x		=		

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries	x			Not applicable
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Spring-run Chinook salmon Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Spring-run Chinook salmon Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to increase survival or efficiency of passage.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
Adult Spring-run Chinook salmon Migration Upstream of the CRS to the Spawning Areas	Fish status and trend monitoring		x	=	
	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)		x		Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring		x	=	

3.1.4 Middle Columbia River Salmonid Species

3.1.4.1 Middle Columbia River Steelhead

This section examines the status of the MCR steelhead, the status of the MCR steelhead critical habitat, and the effects of the Proposed Action on MCR steelhead.

STATUS OF THE MIDDLE COLUMBIA RIVER STEELHEAD DPS

The MCR steelhead DPS was first listed under the ESA on March 25, 1999, at which time it was classified as a threatened species (64 FR 14517). That status was reaffirmed on January 5, 2006 (71 FR 834), and then again on April 14, 2014 (79 FR 20802). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52630).

The status of a species is based on an assessment of extinction risk and is a function of abundance, productivity, spatial structure, and diversity; this assessment describes the species' potential for survival and recovery. Those parameters are, in part, included in listing decisions, status reviews, and recovery plans. The most recent status review (NWFSC (Northwest Fisheries Science Center) 2015) used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis. Recent status reviews of the MCR steelhead by NMFS (NWFSC (Northwest Fisheries Science Center) 2015; NMFS 2019) suggest that while some populations are "viable," the DPS as a whole still warrants a threatened status (NMFS 2019). The status of the critical habitat within the designated range is based on the functionality of the PBFs that are used to develop the conservation value (NMFS 2019). A brief summary of the current status of MCR steelhead is provided below.

The MCR steelhead DPS includes all naturally spawned anadromous steelhead originating downstream of natural and human-made impassable barriers within the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) and extending upstream to and including the Yakima River (Figure 3-21). Within this area, the DPS consists of 19 historical populations, two of which are extirpated.

Extant populations are categorized within four MPGs and include the Cascades Eastern Slope Tributaries, the John Day River, the Yakima River, and the Umatilla and Walla Walla Rivers (Table 3-42). This DPS includes steelhead from four artificial propagation programs: the Touchet River Endemic Program; Yakima River Kelt Reconditioning Program (in Satus Creek, Toppenish Creek, Naches River, and upper Yakima River); Umatilla River Program; and the Deschutes River Program. This DPS does not include steelhead that are designated as being part of an experimental population (79 FR 20802).

The most recent 5-year status review of MCR steelhead (NWFSC (Northwest Fisheries Science Center) 2015) indicated there have been improvements in the viability ratings for some populations, but the MCR steelhead DPS as a whole is not currently meeting the viability criteria. In the 2015 status review, NMFS concluded that returns of natural-origin MCR steelhead to the majority of populations in two of the four MPGs increased relative to the levels reported in the previous 5-year review (Ford 2011). However, they also found that abundance estimates for two of three populations with sufficient data in the remaining two MPGs (Cascades Eastern Slope Tributaries and Walla Walla and Umatilla Rivers) were marginally lower than previously found. In addition, NMFS found that three of the four MPGs in this DPS include at least one population rated at low risk for abundance and productivity. Stray levels from hatchery fish into the John Day River²⁰ populations have decreased in recent years (NMFS 2019), reducing the population diversity viability risks. However, out-of-basin hatchery stray proportions, although reduced, remain high within the Deschutes River Basin populations.

Based on their overall findings, NMFS (2019) concluded in their 2019 BiOp that

. . . Overall viability ratings for the populations in the MCR steelhead DPS remained generally unchanged from the prior five-year review (NWFSC (Northwest Fisheries Science Center) 2016). One population, Fifteenmile Creek, shifted downward from viable to maintained status as a result of a decrease in natural-origin abundance to below its ICTRT minimum abundance threshold. The Toppenish River population (in the Yakima MPG) dropped in both estimated abundance and productivity, but the combination remained above the five percent viability curve, and, therefore, its overall rating remained viable. The majority of the populations showed increases in estimates of productivity (NWFSC (Northwest Fisheries Science Center) 2015).

MCR steelhead experienced a recent reduction in adult abundance, primarily due to recent poor ocean conditions (NWFSC (Northwest Fisheries Science Center) 2015; NWFSC (Northwest Fisheries Science Center) 2016). Recent data indicate improving trends in some ocean indicators that correlate well with higher adult steelhead abundance, however, overall ocean conditions in 2018 were still impacted by recent warming trends (Weitkamp 2018).

²⁰ No hatchery fish are released into the John Day River, so all hatchery fish found there are strays from other programs.

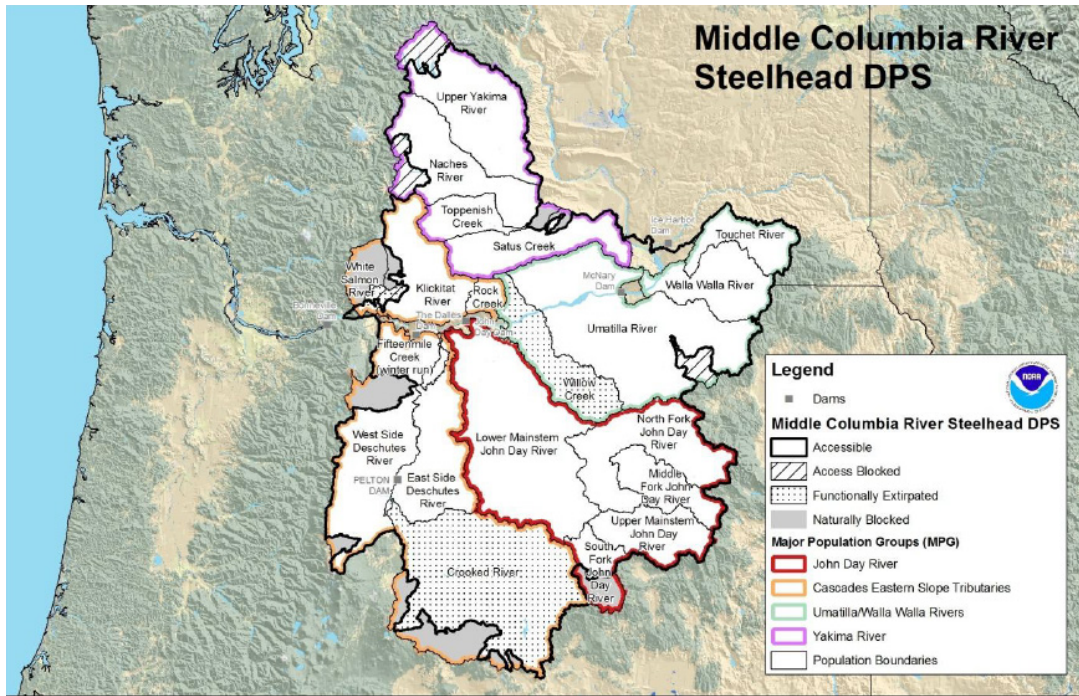


Figure 3-21. MCR steelhead DPS spawning and rearing areas, illustrating populations and MPGs [reproduced from NMFS (2011b)]

Table 3-42. MCR steelhead MPGs, populations, and viability status (Jones 2015; NWFSC (Northwest Fisheries Science Center) 2015; NMFS 2019)

Major Population Group	Populations	Status of Population (overall viability rating)
Natural Production		
Cascades Eastern Slope Tributaries	Deschutes River Eastside	Viable
	Deschutes River Westside	High Risk
	Fifteenmile Creek	Maintained
	Klickitat River*	Maintained
	Rock Creek*	High Risk
John Day River	John Day River Lower Mainstem Tributaries	Maintained
	John Day River Upper Mainstem Tributaries	Maintained
	North Fork John Day River	Highly Viable
	Middle Fork John Day River	Viable
	South Fork John Day River	Viable
Yakima River	Naches River	Moderate Risk
	Satus Creek	Viable
	Toppenish Creek	Viable
	Yakima River Upstream Mainstem	High Risk
Umatilla/Walla Walla Rivers	Touchet River	High Risk
	Umatilla River	Maintained
	Walla Walla River	Maintained
Artificial Production		
Hatchery Programs Included in the distinct population segment (DPS) (n = 7)	Touchet River Endemic, Yakima River Kelt Reconditioning (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River), Umatilla River, Deschutes River	NA
Hatchery Programs Not Included in DPS (n = 4)	Lyons Ferry National Fish Hatchery, Walla Walla River, Skamania Stock, Skamania Stock*	NA

Note: Populations with * are winter-run steelhead populations. All other populations are summer-run steelhead populations.

FACTORS AFFECTING THE STATUS OF MIDDLE COLUMBIA RIVER STEELHEAD

Within the middle Columbia River tributaries that support the spawning and rearing of MCR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. These activities include agriculture, forestry practices, and human development. Impacts associated with these activities include impaired tributary fish passage and degraded freshwater habitat, including reduced floodplain connectivity and function, degraded channel structure and complexity, reduced riparian areas and large woody debris recruitment, reduced streamflow, and reduced water quality (NMFS 2019).

Factors that occur during other life phases of the MCR steelhead also have profound impacts on the status of the species and include genetic diversity effects from out-of-population hatchery releases, predation, adverse mainstem Columbia River hydropower-related effects, degraded ocean conditions, and harvest (NMFS 2019).

With a decline in salmonid production, and as a result a decline in spawners within natal streams, nutrients vital to juvenile production have also decreased dramatically. Gresh et al. (2000) estimated that since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only about 6–7 percent of historical levels. They attributed this decline to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. These nutrients are important for salmonid production, and consequently for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2000).

Over a total life cycle, the greatest incidence of mortality occurs where MCR steelhead spend most of their life, i.e., in tributary and early ocean environments (see Section 3.2.1.1, Figure 3-1). Tributary survival of juvenile steelhead varies depending on habitat and climate conditions and the carrying capacity of the natal stream (Thurow 1987; Chapman et al. 1994). Quinn (2005), using average values from more than 200 studies, found that egg-to-emigrant (smolt) survival for steelhead averages 1.4 percent. Smolt-to-adult survival has been measured for at least two of the MCR steelhead populations, and it averages less than 10 percent (Bare et al. 2019; Frederiksen et al. 2019).

Widener et al. (2019) compiled estimates of survival for juvenile steelhead migrating downstream through the Snake and lower Columbia Rivers. Survival estimates represented empirical estimates for specific geographic reaches, which, depending on the area of inference, could be from the forebay to the tailrace of a specific dam (dam passage survival), or from one dam (e.g., tailrace of McNary Dam) to another dam (e.g., tailrace of Bonneville Dam) (reach survival). No estimates were available for MCR steelhead, but estimates were available for steelhead released in the Snake River. SR steelhead can be used as a surrogate for MCR steelhead in this case when looking at survival through the lower Columbia River CRS dams.

Below, we discuss factors affecting the status of MCR steelhead by life stage.

Freshwater Spawning, Rearing, and Migration to the CRS

MCR steelhead use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. While many of the habitat modification are relics of past anthropogenic practices, NMFS identified factors limiting viability in the MCR in tributary areas that continue to influence productivity. The 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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition.

Human activities (threats) 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 (NMFS 2019).

The consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. The ISAB (2015) provided evidence for strong density dependence at current abundance levels for anadromous salmon and steelhead and suggests that habitat capacity has been greatly diminished. Density dependence was observed in most rivers where data have been examined and includes 26 of 28 interior Columbia Basin Chinook salmon populations and all 20 interior Columbia Basin steelhead populations, despite natural spawners being much less abundant currently relative to historical abundance (ISAB 2015).

In an assessment of density dependence using a two-stage Gompertz model, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages and concluded that due to density dependence during the parr-to-adult stage, a greater number of fish reaching the ocean may not substantially increase the number of adults reaching the spawning grounds. Based on this evidence, the authors concluded the following:

This suggests that life cycle modeling to date has been overly optimistic about the benefits of survival rate increases in the hydrosystem and elsewhere to improve the viability of salmon populations threatened with high extinction risk.

While the modeling framework of Hinrichsen and Paulsen (2019) was applied to SR spring/summer Chinook, it is reasonable to assume that steelhead are also experiencing similar effects of density dependency.

Past and present effects of the existence of CRS dams and past operations: MCR steelhead are not exposed to the CRS facilities or operations during adult holding, spawning, egg incubation, and juvenile rearing and migration within the tributary environment.

Past and present effects of hatcheries: Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They can also help preserve genetic resources until factors limiting natural productivity 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 strays pose significant risk to many of Oregon's MCR steelhead populations, particularly to the Eastside and Westside Deschutes and John Day populations (NMFS 2019). Viability assessments determined that a significant proportion of spawners in the Deschutes River and John Day River populations were out-of-DPS strays; however, some out-of-basin steelhead migrating into the Deschutes River appear to be seeking thermal refugia and eventually return to their natal streams (Keefer et al. 2016). In addition, these populations were rated at high risk for spawner composition due to the abundance of strays. Biologists remain especially concerned about the continuing detrimental impact of out-of-DPS hatchery fish in natural spawning areas on the genetic traits and productivity of these natural populations. The 5-year status review conducted in 2015 noted a decrease in the proportion of strays in the John Day River Basin (NWFSC (Northwest Fisheries Science Center) 2015). It is unclear whether this trend is temporary or whether it will continue to decrease with improved hatchery-management and transportation (barging) practices.

Hatchery programs operated within the MCR steelhead DPS, including the Umatilla, Walla Walla, Touchet, and Westside Deschutes subbasins, also create some risks due to ecological interactions and genetic introgression. For the hatchery programs that incorporate natural-origin adults into the broodstock, or were derived from the endemic population, NMFS has determined that these hatchery programs have not changed substantially or in a way to suggest that their level of divergence relative to the local population differs from what would be expected between closely related natural populations within the DPS (Jones 2015).

Juvenile MCR Steelhead Downstream Migration Through the CRS

MCR steelhead populations from the Cascades Eastern Slope Tributaries MPG pass one to two CRS dams on their downstream migration, depending on the stream of origin. Populations originating from the John Day and Umatilla Basins migrate through three mainstem dams and reservoirs and populations originating from the Yakima and Walla Walla Rivers migrate through four mainstem dams and reservoirs.

Past and present effects of CRS existence and past operations: Through the CRS, juvenile MCR steelhead have been and continue to be exposed to the effects of both CRS operations and the existence of the CRS dams. Juvenile MCR steelhead pass downstream of dams by many routes. Routes of passage include spillways and surface passage structures, juvenile bypass systems, and turbines units. Major modifications have been made to CRS dams and operations to improve survival and achieve the 2008 BiOp juvenile dam passage performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project (Table 3-43).

Table 3-43. Average fish passage efficiency and dam passage survival estimates for juvenile steelhead passing CRS dams [based on Table D-1 and D-2 from Bonneville et al. (2018a)]

Dam	Year of Studies	FPE	Year of Studies	Average Survival Estimate
Bonneville	NA	NA	2010, 2011	97
The Dalles	NA	NA	2010, 2011	97
John Day	2012	97	2011, 2012	98
McNary	2012, 2014	93	2012, 2014	98

Past modifications include the installation of surface passage systems, improved turbine designs, and upgrades of screened bypass systems to improve how and where fish are returned to the river downstream from dams, as well as spill operations tailored to the unique structural configuration of each dam (Bonneville et al. 2017). A summary of these improvements is provided in Appendix A of Bonneville et al. (2017), and is incorporated by reference here. However, the actions that have benefited MCR River steelhead can be summarized as follows:

- Minimize winter drafts of the large upper basin storage reservoirs (for flood risk management and power generation) to save water for augmenting spring flows during the peak juvenile passage period (water quantity).
- Construct JBSs and surface passage structures and provide spill at the run-of-river dams to divert smolts away from turbine units (safe passage) and reduce potential delay in the forebays.

- Install safer turbines for fish passage.
- Reduce TDG through multiple actions and plans.
- Manage avian and fish predators through multiple actions and plans.

For SR steelhead (hatchery and wild combined) cohort years 1997 to 2018, from McNary Dam to Bonneville Dam, reach survival rates averaged 0.68 (Widener et al. 2019). However, if these estimates are broken into specific time periods, the average reach survival estimate from McNary Dam to Bonneville Dam for years 1997 through 2008 (there were no estimates in 2004 and 2005 for this reach) was 0.57, while from 2009 through 2018, survival increased substantially to 0.79 (Widener et al. 2019). Comparing the reach from McNary to Bonneville Dam suggests that MCR and SR steelhead survive at very similar rates (Table 3-44).

Table 3-44. Comparison of survival of SR steelhead (wild and hatchery, and wild only) and UCR hatchery steelhead through the lower Columbia River System federal dams. Hydropower system survival estimates were derived by combining empirical survival estimates, 2003–2018 [based on Tables 30, 31, and 33 from (Widener et al. 2019)].

Origin	Average Survival: McNary Dam to Bonneville Dam
Snake River wild	0.642
Snake River wild and hatchery	0.731
Upper Columbia hatchery	0.774

Because survival of fish passing the dams via non-turbine routes is higher than through turbines, passage facilities are designed and operated to increase the likelihood of juvenile fish passage through non-turbine routes. The metric by which this is measured is referred to as FPE. Depending on the location and time of year, more than 90 percent of juvenile steelhead use these non-turbine routes at the four lower Columbia River dams (Bonneville et al. 2017)(Table 3-43).

As discussed previously, Widener et al. (2019) compiled estimates of survival for juvenile steelhead migrating downstream through the Snake and lower Columbia Rivers. However, those estimates included data for years preceding major physical and operational modifications to the CRS, and therefore, the estimates of survival do not fully express the benefits realized by the modifications. After the structural and operational modifications implemented after the 2008 BiOp, survivorship improved through the CRS (Bonneville et al. 2017).

In addition, TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can get forced into solution when water passes over the spillway at a mainstem dam, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019).

Past and present effects of predator management: Survival of MCR juvenile steelhead is affected by avian and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple 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. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019).

Juvenile MCR Steelhead Estuary Migration and Rearing, Including the Plume

The estuary provides important habitat for MCR steelhead populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also affected estuary ecosystems. For a more detailed discussion of estuary and plume conditions, see NMFS (2019). All these conditions are part of the environmental baseline.

Past and present effects of CRS existence and past operations: While there are no CRS facilities in the estuary (defined as Bonneville Dam to the ocean), past CRS management affected the timing and volume of flows, as well as temperature, sediment load, and TDG levels in this area. The effects of CRS management actions generally decrease as distance from Bonneville Dam increases and estuary hydrodynamics become less fluvially influenced. In particular, flow regulation and reduced sediment recruitment caused by the CRS have likely negatively affected habitat-forming processes in the estuary, habitat that supports the juvenile life stage of all Columbia River Basin anadromous fish populations.

Estuarine floodplain habitat is important for outmigrating juvenile salmon and steelhead, including MCR steelhead. To help maintain and improve the overall status of salmon and steelhead in the Columbia River Basin, the Action Agencies actively work to restore and conserve habitat in the Columbia River estuary through the CEERP. These restoration actions affect salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit of estuary restoration is that wetland food production supports foraging and growth within the wetland [Johnson et al. (2018) as cited in NMFS (2019)]. Prey items (primarily chironomid insects and corophiid amphipods [PNL/NMFS (2018) as cited in NMFS (2019)]) produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest 5-year review of the CEERP (Johnson et al. 2018), have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide-gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity below Bonneville Dam [Johnson et al. (2018) as cited in NMFS (2019)]. In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past and present effects of predation management: A variety of avian species (especially Caspian terns and double-crested cormorants) have historically been a major source of predation on juvenile salmonids in the estuary. While avian predators continue to prey upon juvenile salmonids, including MCR steelhead, predation rates have declined due to a variety of management efforts. For example, between 2007 and 2010, the average predation on MCR steelhead by Caspian terns and double-crested

cormorants from East Sand Island (near the mouth of the Columbia River) was approximately 15% and 10%, respectively (Evans et al. 2018). However, from 2011 to 2017, the average for Caspian terns and double-crested cormorants dropped to 9.1% and 5.5%, respectively (Evans et al. 2018). The efforts to reduce avian predation are discussed in detail in the 2019 BiOp and are incorporated by reference here (NMFS 2019). NMFS (2019) has noted that the success of implementing the avian management plans at meeting underlying goals, but the results may be uncertain at this time because birds have relocated to other areas within the estuary.

Ocean Rearing

MCR steelhead typically spend 1 to 2 years rearing in the ocean (NMFS 2009). Variability in marine ecosystem productivity can be a major factor determining adult steelhead run size (NMFS 2014a). Since about 2014, poor ocean conditions have contributed to declines in ocean survival and associated adult returns. In the 2019 BiOp, NMFS provided a detailed discussion of ocean conditions, factors that affect the ocean environment, and impacts on MCR steelhead. That information is incorporated here by reference; a brief summary follows.

Factors that influence ocean conditions are also likely to affect the survival of MCR steelhead. The consequences of climate change will likely include increased water temperatures, more severe El Niño events, worsened ocean acidification, and major alterations in the northeast Pacific Ocean marine ecosystem associated with the Pacific Decadal Oscillation (NMFS 2019). These factors will affect MCR steelhead survival either directly or indirectly because of their deleterious impacts on marine food webs.

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in distribution of aquatic marine organisms. Many species that typically occur in more southerly waters, moved northward from southern California to Alaska in the unusually warm water during 2014 and 2015, which was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Pearcy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt marine ecosystems in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean and past CRS operations have had no direct effect on this DPS during ocean residence. Welch et al. (2018) concluded that marine survival of west coast Chinook and steelhead populations has collapsed over the last half century for most regions of the west coast. Based on their review of annual survival estimates for Chinook and steelhead, they concluded the following:

We found that marine survival collapsed over the past half century by a factor of at least 4-5-fold to similar low levels (~1%) for most regions of the west coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Another factor that should be considered is delayed, or latent, mortality. Delayed mortality is a term for harm caused when an animal survives one event or circumstance but incurs damage that only shows up

later and may be expressed as illness or death. With Columbia River Basin salmon and steelhead, the term is commonly applied in situations such as barging or dam passage of salmon or steelhead smolts. The term “latent mortality” is generally used more specifically to apply to the effects of dam passage. While most or all of the fish might survive the act of barging or migrating in-river past the dam, the delayed mortality hypothesis holds that, as a result of passing a dam, a smolt is less healthy than it would be otherwise and therefore less likely to survive in the ocean and return as an adult.

The ISAB (2012) concluded, after reviewing various studies, that their analyses demonstrated that fish bypass systems are associated with some latent mortality, but the factors responsible for latent mortality remain poorly understood and are inadequately evaluated; further:

The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis).

Past and present effects of harvest: Harvest of steelhead in the ocean is rare (NMFS 2019).

Adult MCR Steelhead Migration to Bonneville Dam

Adult steelhead migrating upstream after ocean residence typically do not feed within the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume, and a migratory corridor free of obstructions to access spawning areas (NMFS 2019). Populations of MCR steelhead enter the Columbia River estuary and pass over Bonneville Dam as early as May, but most migrants are observed from June 1 through the end of October, and the peak migration occurs in early August (Keefer et al. 2016).

For upstream migrating MCR steelhead, the primary factor affecting survival to Bonneville Dam is pinniped predation. Estimates of pinniped predation downstream of the Bonneville Dam tailrace are not available for adult steelhead from any DPS, although salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). The ODFW has documented an increase in the monthly counts of California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, during the month of September. For the years of 2008 to 2014, the number of California sea lions observed averaged fewer than 500 animals; for 2015 and 2016, that average increased to more than 1,000 individuals (NMFS 2019).

The abundance of pinnipeds in the Bonneville Dam tailrace has increased over the course of the last 6 years (Tidwell et al. 2018). In a subsequent study, Tidwell et al. (2018) documented an average of 14.5 Stellar sea lions between July 21 and December 31, 2017, and on numerous occasions observed more than 20 individuals. Based on adjusted consumption rates, Tidwell et al. (2018) estimated a consumption rate of 1.54 percent for all steelhead collectively and concluded that the estimate is a reasonable rate of consumption of MCR steelhead. Average pinniped impacts on summer migrating adult MCR steelhead are likely relatively small 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 (NMFS 2019).

Past and present effects of CRS dams and past operations: No CRS dams impede migration in the lower Columbia River as these fish migrate upstream to Bonneville Dam. As previously mentioned, adult MCR steelhead enter the Columbia River from May through October, and the Action Agencies are required to spill water over the CRS dams to increase the survival of juvenile fish migrating downstream during a large portion of that time. As such, adults may be exposed to higher levels of TDG, which may influence their migration behavior or increase their chances of GBT (NMFS 2019). TDG levels are mitigated to some extent downstream from Bonneville Dam because of gas dissipation and the mixing of water with lower TDG levels from tributaries such as the Willamette River.

Past and present effects of harvest: Harvest mortality in fisheries downstream of Bonneville Dam have been reduced substantially in response to evolving conservation concerns and restrictions for ESA-listed species. Historically, MCR steelhead were harvested in both non-treaty commercial fisheries, as well as in recreational fisheries in the area downstream of Bonneville Dam to the river mouth. In response to declining steelhead abundance, non-treaty commercial harvest of steelhead was prohibited in 1975, and treaty commercial harvest has been reduced and restricted to clipped (hatchery-origin) fish. As such, the harvest of non-clipped fish is incidental. Also, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986.

Adult MCR Steelhead Migration Through CRS Dams

MCR steelhead populations migrate upstream through one to four lower CRS projects on their way to natal spawning areas. During upstream migration, these fish experience a variety of factors affecting the adult migration life stage, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish [NMFS (2008b); Keefer et al. (2016); and Keefer and Caudill (2017) as cited in NMFS (2019)]. The primary factors influencing safe, timely, and effective adult upstream passage through CRS dams are tailrace flow dynamics, sufficient attraction flows to fish ladder entrances, operating ladders within criteria, reducing fallback, and maintaining safe ladder temperature and differentials (NMFS 2019).

In addition, steelhead that survive spawning and try to return to the ocean (kelts) can be affected by the CRS. CRS-related mortality of downstream migrating kelts is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 40 and 45 percent of SR 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 and 67 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. 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 (NMFS 2019).

Past and present effects of CRS existence and past operations: Under typical conditions, after accounting for reported harvest rates and expected stray rates, adult MCR steelhead have relatively high conversion

rates²¹ passing the lower Columbia River CRS dams (NMFS 2019). NMFS (2019) used adjusted conversion rates of PIT-tagged SR steelhead migrating through the CRS as a surrogate for MCR steelhead, and determined that the 5-year rolling average of 88.9 percent survival from Bonneville to McNary Dam served as a reasonable estimate of survival through the CRS for MCR steelhead.

These estimates of minimum survival also account for impacts associated with fallback at CRS projects, such as direct and indirect mortality associated with the fallback event, delay, straying, etc. Mean annual fallback rates at lower Columbia River dams is about 6 to 9 percent [Keefer et al. (2016) as cited in NMFS (2019)]. Based on the relatively high survival estimates, NMFS concluded that upstream passage conditions for adult MCR steelhead are not substantially impaired as fish migrate through impounded reaches of the lower Columbia River (NMFS 2019).

Keefer et al. (2007) found that winter fallback-related²² mortality is almost certainly not distributed evenly among populations of MCR steelhead, 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) estimated the relative survival impacts of winter (November–April) fallbacks by steelhead at CRS projects and found that fallback in March and November had the largest negative effect on fish survival, and The Dalles Dam had the largest negative effect on survival across the winter study months for MCR steelhead.

Each year, when the mainstem Columbia River temperature increases to above 64°F in the summer months, a large portion of MCR steelhead (including 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 (NMFS 2019).

Past and present effects of predator management: As discussed previously, the presence of pinniped predators has increased within the Bonneville Dam tailrace in recent years; there have been occasional pinniped observations in the Bonneville reservoir when MCR steelhead are present [Tidwell et al. (2018) as cited in NMFS (2019)]. To restrict entry of pinnipeds into the ladder systems at Bonneville Dam, the Corps constructed structures to physically exclude pinniped entry into fishways, while allowing upstream migration of adult salmonids. These structures have been installed at all eight fishway entrances at Bonneville Dam (NMFS 2019).

Average pinniped impacts on summer migrating adult MCR steelhead are likely relatively small 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 (NMFS 2019).

Past and present effects of harvest: Steelhead in the lower Columbia River are primarily harvested during what managers term the “fall season.” During the fall management period, fisheries target

²¹ Conversion rates are simply the percentage of adult salmonids passing an upstream dam that passed a downstream dam ($\frac{\# \text{ passing}_{\text{upstream dam}}}{\# \text{ passing}_{\text{downstream dam}}}$). Conversion rate is used as a surrogate for survival, but factors (other than mortality) may affect the number of adult fish passing the upstream dam (e.g., tag not detected), so a conversion rate is not specifically an accurate measure of survival.

²² Winter fallback occurs when MCR steelhead migrate upstream of their natal stream during their initial upstream migration from the ocean, and then seek to return to their natal stream and have to pass one or more dams.

primarily harvestable hatchery and natural-origin fall Chinook and coho salmon and hatchery steelhead. Fall season fisheries are constrained by specific ESA related harvest rate limits for listed SR fall-run Chinook salmon, and both A-Index and B-Index components of the listed UCR and SR steelhead DPSs.

A-Index summer steelhead are caught in summer sport fisheries downstream of Bonneville Dam and during fall through the following spring season in fisheries upstream. Non-treaty fisheries are subject to a 2 percent harvest rate limit for A-Index summer steelhead in summer (from July 1 through July 31) and then from January 1 through the following spring since these are the same run of steelhead that have now migrated upstream in the Columbia River Basin. The total annual harvest rate limit for A-Index summer steelhead is 4 percent. The incidental catch of winter steelhead in non-treaty across all fisheries has averaged 1.9 percent since 2008. The yearly incidental catch of A-Index summer steelhead in non-treaty fisheries has averaged 1.9 percent since 2008 compared to the 4 percent yearly combined limits. Harvest rates are not expected to change over the course of the 2018 *US v OR* Agreement (U.S. v. Oregon 2018).

There are no specific incidental harvest rate limits for treaty fisheries on the MCR steelhead DPS. The BiOp for the *U.S. v Oregon* ongoing process expects incidental harvest impacts on the winter steelhead stock and A-Index surrogate components for the MCR steelhead DPS associated with treaty tribal fisheries to be the same as the range observed in earlier years—between 1.4 percent and 6.9 percent for the winter steelhead stock and 4.6 percent and 12.9 percent on the A-Index stocks (U.S. v. Oregon 2018). However, the expected incidental harvest impacts on the winter stock and A-Index components of the MCR steelhead DPS in treaty fisheries are expected to be less. The harvest rate for treaty fisheries on the winter steelhead stock in the Bonneville pool from 2008 to 2017 averaged 0.5 percent and ranged from 0.1 percent to 1.4 percent. The harvest rate for treaty fisheries on the unclipped A-Index stock in the Bonneville pool from 2008 to 2017 averaged 1.6 percent and ranged from 0.7 percent to 7.0 percent during the summer and subsequent winter/spring combined seasons and averaged 6.5 percent and ranged from 4.0 percent to 10.0 percent during the fall seasons (U.S. v. Oregon 2018).

Adult MCR Steelhead Migration Upstream of the CRS to the Spawning Areas

Within the middle Columbia River tributaries that support the spawning and rearing of MCR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

Low flows and high summer temperatures in tributary habitats can effectively create temporary migration barriers that reduce habitat access until conditions improve. These impacts on water quality in tributary habitat can affect the run timing and survival 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 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).

Past and present effects of harvest: Recreational fisheries for steelhead in MCR tributaries and mainstem Columbia River upstream of the CRS result in incidental impacts on natural-origin fish to some unknown degree. Of the fish that are caught and released, it is assumed that 10 percent will die from handling-related injuries (NMFS 2019).

STATUS OF CRITICAL HABITAT

In this section of the BA, the status of critical habitat is reviewed for MCR steelhead. Critical habitat includes the stream channels within designated stream reaches and to an extent is defined by the ordinary high-water mark (33 CFR §319.11). The PBFs of critical habitat that are essential to the conservation of MCR steelhead have been identified and include freshwater spawning, rearing and migration corridors, as well as estuarine and nearshore marine areas (Table 3-4) (NMFS 2019).

Critical habitat for the MCR steelhead DPS was designated on September 2, 2005 (70 FR 52630). Critical habitat for MCR steelhead was designated in the following watersheds (including major tributaries): Yakima River, the mainstem Columbia River, the Walla Walla subbasin, the Umatilla River watershed, the Fifteenmile Creek subbasin, the Fivemile Creek watershed, the Mosier Creek watershed, the White Salmon River watershed, the Klickitat River watershed, the John Day River subbasin, the Rock Creek watershed, and the Deschutes River Basin.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation 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 MCR steelhead.

Table 3-45. PBFs and components and principal factors affecting the environmental baseline of critical habitat designated for MCR steelhead [reproduced from NMFS (2019); Table 2.9-11; Page 336]

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
Freshwater spawning sites	Water quantity and quality conditions and substrate supporting spawning, incubation, and larval development	Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage) Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage) Diminished streamflow (degraded water quantity, elevated temperatures, loss of juvenile and adult mobility) Impaired fish passage (obstructions, water withdrawals) Excess fine sediment in spawning gravel (degraded water quantity) Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation)

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
Freshwater rearing sites	<p>Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility</p> <p>Water quality and forage supporting juvenile development</p> <p>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</p>	<p>Impaired fish passage (obstructions, water withdrawals)</p> <p>Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations)</p> <p>Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)</p> <p>Reduced floodplain conditions and connectivity (loss of side channels, natural cover, vegetation, and forage)</p>
Freshwater migration corridors	<p>Free of obstruction and excessive predation 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</p>	<p>Delay and mortality of adults (at up to eight mainstem dams)</p> <p>Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human built structures used by terns and cormorants for nesting)</p>
Estuarine areas	<p>Free of obstruction and excessive predation, with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater</p> <p>Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels</p> <p>Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation</p>	<p>Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage) and the presence of toxic contaminants (reduced water quality and forage).</p>
Nearshore marine areas ^a	<p>Free of obstruction and excessive predation, with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation</p>	<p>Concerns about increased opportunities for pinniped predators and adequate forage</p>
Offshore marine areas	<p>Not designated</p>	

^a The designated nearshore marine area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

As discussed previously, MCR steelhead enter the Columbia River estuary and pass over Bonneville Dam as early as May, but most migrants are observed from June 1 through the end of October, and peak migration occurs in early August (Keefer et al. 2016). Migration of MCR steelhead through the CRS and areas upstream is complicated because of various environmental factors that affect migration. Based on PIT detections, NOAA Fisheries (2019) estimated that 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. This is evidence of tributary overshoot, which can have additional impacts on survival as adults migrate downstream to natal tributaries.

All steelhead spawn in gravel and cobble substrates that are largely free of fine sediments. Developing eggs require cool, clean, and well-oxygenated waters for proper development. Juvenile MCR steelhead usually spend 2 years in freshwater but may remain longer depending on water temperature and growth. Juvenile migration to the ocean occurs during the spring freshet during the months of March through mid-June (NMFS 2019).

During their freshwater residence, juvenile salmon need abundant food sources and instream cover to protect them from predators. Juvenile fish cover may include undercut banks, overhanging vegetation, logs and root wads, and large substrate (NMFS 2019). Off-channel habitat, side channels and other low stream velocity areas provide refuge during high flow event. Cool waters offered by springs, seeps, and deep pools offer refuge when stream temperature increases during the summer. Interstices offered by large substrate allow juveniles to seek refuge during the winter.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of MCR steelhead. Spawning and rearing occurs in the Deschutes River Basin (Eastside and Westside), Fifteenmile Creek, Klickitat River, Rock Creek, John Day River Basin (lower mainstem tributaries, upper mainstem tributaries, North Fork, Middle Fork, and South Fork), Yakima River Basin (Naches River, Satus Creek, Toppenish Creek, Yakima River upstream mainstem), Umatilla River, and Walla Walla River Basin (Touchet River).

The quality of tributary habitat for MCR steelhead varies substantially throughout the middle Columbia River region; some spawning and rearing habitat is in near pristine conditions, while other areas are minimally to highly degraded due to past human activities (NMFS 2019). Habitat throughout the tributaries of the interior Columbia River Basin has been degraded by several activities, including agriculture, alteration of stream morphology (i.e., channel modifications and diking), disturbance of riparian vegetation, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, timber harvest, mining, and urbanization [Lee et al. (1997) as cited in NMFS (2019)]. These activities have led to factors that limit the viability of MCR steelhead. These factors include (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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel instability are common symptoms of ecosystem decline in areas of critical habitat. Lack of adequate summer streamflows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas of the interior Columbia River Basin. Large-scale habitat assessments in the interior Columbia River Basin indicate that in watersheds managed for natural resources extraction, the number of large pools has decreased from 87 to 20 percent [McIntosh et al. (1994) as cited in NMFS (2019)].

To address these issues and to mitigate impacts associated with the operation of the CRS, the Action Agencies, in cooperation with private, local, state, tribal and federal entities, have implemented a variety of tributary habitat restoration actions throughout the MCR region to benefit MCR steelhead since 2007; those restoration actions are summarized in Table 3-5.

Table 3-46. Tributary habitat improvement metrics: MCR steelhead, 2007–2015 [reproduced from NMFS (2019); Table 2.9-6; Page 318]

Action Type ^a	Amount Completed
Acre-feet per year of water protected (by efficiency improvements and water purchase/lease projects)	94,135.5
Acres protected (by land purchases or conservation easements)	42,823.5
Acres treated (to improve riparian habitat, such as planting native vegetation or controlling noxious weeds)	7,488.7
Miles of enhanced or newly accessible habitat (by providing passage or removing barriers)	1,857.6
Miles of improved stream complexity (by adding wood or boulder structures or reconnecting existing habitat, such as side channels)	157.5
Miles protected (by land purchases or conservation easements)	1,139.4
Screens installed or addressed (for compliance with criteria or by elimination/consolidation of diversions)	265

^a Several of these categories (i.e., acres protected, acres treated, miles of enhanced stream complexity and miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

In the 2019 BiOp, NMFS (2019) concluded the following:

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have 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 ISAB (2015) has pointed out that there is compelling evidence for strong density dependence at current abundance levels for anadromous salmonids and suggests that habitat capacity has been greatly diminished. The ISAB also suggests that changes in environmental conditions within habitats accessible to salmon and steelhead stemming from climate change, chemicals, and intensified land use appear to have further diminished habitat capacity. The ISAB (2015) found that density dependence was observed in all 20 interior CR steelhead populations during the 1980 to 2008 brood years.

The ISAB (2015) has noted that studies of density dependence during the spawning and incubation stage are rare. In addition, other factors besides density dependence, such as sedimentation, streamflow, water temperatures, and winter freezing conditions, can be responsible for significant mortality during spawning and incubation. The ISAB (2015) concludes by stating that both the UCR and Snake River Basin steelhead DPSs show density-dependent interactions have a strong effect on recruitment of adults. And

while few studies have examined the main cause of the observed density dependence (i.e., limitations in spawning vs. rearing habitat) in steelhead, they suggest that the effect is most likely related to interactions during rearing more so than during spawning stages, and that further study is necessary to confirm this.

Key recommendations from the ISAB (2015) included the following: (1) account for density effects when planning and evaluating habitat restoration actions; (2) establish biological spawning escapement objectives that account for density dependence; (3) balance hatchery supplementation with the Columbia River Basin's capacity to support existing natural populations by considering density effects on the abundance and productivity of natural-origin salmon; and (4) improve capabilities to evaluate density-dependent growth, dispersal, and survival by addressing primary data gaps.

Freshwater Migration Corridors

The freshwater migration corridor extends from the spawning and rearing areas in the middle Columbia River subbasins downstream to the Columbia River plume. Migration corridors are considered essential to the conservation of MCR steelhead. Human activities that have affected habitat in subbasin tributary reaches have already been discussed and contribute to the quality and quantity of water downstream and within the migration corridor of the Columbia River. Already-implemented tributary habitat actions support all MPGs of MCR steelhead and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, removing barriers to spawning and rearing habitat, and other actions targeted at addressing limiting factors (NMFS 2019). No CRS projects exist in the freshwater tributary corridors, and MCR steelhead are not exposed to any CRS operations until they reach the mainstem Columbia River reservoir created by the first dam they encounter.

The quality of designated critical habitat within the lower Snake River and lower Columbia River migration corridor is a function of the cumulative impacts of upstream actions, including impacts from development along the corridor, dam operations, and management within the Columbia River that affects both juvenile and adult MCR steelhead. All these factors combine to affect critical habitat in the mainstem and influence the migration corridor. Habitat within the mainstem lower Snake and Columbia Rivers has been substantially altered by a number of factors, including basin-wide water management, the existence and on-going and operation of CRS hydroelectric projects, and other human-related activities that have degraded water quality and habitat (NMFS 2019). In the 2019 BiOp, NMFS describes the factors affecting the behavior and survival of MCR steelhead through the CRS, and that information is included here by reference (NMFS 2019), and briefly summarized below.

Mainstem dams can affect stream temperature, streamflow, gas supersaturation levels, and river habitats. Both the Snake and Columbia Rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Because the temperature regime has been modified, resulting in warmer late summer/fall water temperatures, it potentially affects juvenile and adult salmonids as well as fish community structure. Warmer stream temperatures may influence predation rates on juvenile fish by predatory fish species. Juvenile fish may also be affected when water is spilled from hydroelectric facilities, thereby increasing gas supersaturation, and may lead to GBT in fish. All projects create impoundments that affect riverine habitats and can affect travel times, which may increase fish exposure to both native and non-native

predators. Some passage routes through dams may decrease juvenile fish survival (e.g., turbines) compared to spill bays and surface passage routes that are operated to increase overall juvenile passage survival. The processes, general effects, and mitigation of CRS mainstem dams on the functioning of critical habitat are presented in Table 3-47.

Table 3-47. The processes and effects of the CRS hydroprojects, and mitigation efforts to address the effects

Process	Effect	Mitigation
Passage at hydro projects	Reduced juvenile survival at dams	Surface passage, increased proportion of spill, flow augmentation, TDG management, bypasses, and fish-friendly turbines
Water storage	Altered water quantity and seasonal timing	Flow augmentation
Solar radiation/reduction in mainstem stream velocity	Altered temperature, both in the reaches below the large mainstem storage projects and migration corridors	The dams result in water temperatures that are slightly better (cooler) during the spring migration
Water storage	Reduced sediment transport and turbidity in migration corridors and estuary	NA
Spill	Increased total dissolved gas	System-wide TDG management
Modification of habitat	Altered food webs, including both predators and prey	Avian management, fish bypass outfall placement (away from known predator concentrations), and pikeminnow removal (management)

In July–August, during the peak of the MCR steelhead adult migration, solar radiation adds heat to the water in the top portion of the reservoirs, which can lead to high stream temperatures and water temperature differentials in the fish ladders in the CRS and other hydro projects. Stream temperatures within fish ladders exceeding 68°F and differentials greater than 1.8°F have been demonstrated to cause delay in steelhead migration and can reduce their successful migration to natal tributaries (Caudill et al. 2013). Stream temperatures within fish ladders commonly exceed 68°F and fish ladder differentials regularly exceed 1.8°F while MCR steelhead are migrating [McCann (2018) as cited in NMFS (2019)]. During the most extreme summer days, stream temperatures within fish ladders in CRS dams can exceed 75.0°F, and fish ladder temperature differentials can exceed 4.5°F [FPC (2019) as cited in NMFS (2019)]. Fish ladder cooling structures installed at Little Goose and Lower Granite Dams 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 is ongoing to identify if cooler water is available and can be pumped into fish ladder exits.

Since 2008, when modifications to the physical and operational CRS were first implemented based on the 2008 BiOp, survival of MCR juvenile steelhead and adult migrants has improved substantially. As noted earlier, juvenile survival through individual lower Columbia River CRS dams ranged between 95.34 to 99.52 percent (Bonneville et al. 2018a). During the same time period, the average reach survival rate was 77.4 percent for juvenile hatchery and wild SR steelhead surrogates from McNary Dam to Bonneville Dam.

For adult MCR steelhead for the years of 2008 to 2017, the estimate of minimum survival for the Bonneville to McNary reach averaged 94.3 percent over the 10-year period (range of 90.1 to 100.0 percent). This estimate of minimum survival accounts for all sources of mortality, both natural and anthropogenic, and can also be expressed as a survival rate of 98.1 percent per project (NMFS 2019).

Estuarine and Nearshore Marine Areas

Critical habitat has been designated for MCR steelhead in the Columbia River estuary (NMFS 2019). NMFS has defined the estuary to include the tidally influenced portion of the Columbia River, i.e., from Bonneville Dam (RM 146) to the mouth of the Columbia River, including the lower portions of tributaries influenced by tidal action. As such, the lower 26 miles of the Willamette River are also included within the estuary domain.

NMFS (2019) considers a functioning estuary essential to the conservation of MCR steelhead. NMFS identified the PBFs for MCR steelhead in the estuary to include areas free of obstruction and having water quality, quantity, and salinity conditions that support juvenile and adult physiological transitions between freshwater 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.

NMFS (2019) identified degraded habitat conditions in the estuary as a limiting factor for MCR steelhead. Historically, the Columbia River estuary was more dynamic than it is today. Multiple channels, extensive wetlands, sandbars, and shallow areas, especially in the downstream 50 river miles, were influenced by winter and spring floods, low flows in late summer, large woody debris, and high sediment loads (NMFS 2019). As reported by NMFS (2019), the current conditions of the Columbia River estuary have changed as a result of many factors, including dredging to deepen and maintain the Federal Navigation Channel and the existence of jetties and pile-dike fields to stabilize and concentrate river flow. Causeways have been constructed across waterways. As noted by NMFS (2019), the mouth of the Columbia River was historically about 4 miles wide but has decreased to about 2 miles wide, and the depth has increased at the Columbia River channel at the bar from less than 20 feet to more than 55 feet.

In particular, NMFS (2019) reported a dramatic decrease in wetland areas in the Columbia River estuary. More than 50 percent of the marshes and spruce swamps have been converted to industrial, transportation, recreational, agricultural, or urban areas, involving more than 3,000 acres converted since 1948 (NMFS 2019). In the upper reaches of the estuary, many wetlands on the floodplain have been converted to industrial and agricultural lands after levees and dikes were constructed. As reported by NMFS (2019), 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost since the late 1800s. Those wetlands support salmonid food webs both in shallow water and in the mainstem.

Changes in streamflow and sediment delivery have also affected critical habitat in the Columbia River estuary. NMFS reports that water storage and release patterns from reservoirs upstream have changed the seasonal pattern and volume of discharge within the Columbia River estuary (NMFS 2019). Discharge has increased in the winter and peak spring/summer floods have been reduced. NMFS (2019) also reported that model studies indicate that combined human activities in the Columbia River Basin have

decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine-sediment transport by 50 percent or more. The significance of changes in sediment delivery to MCR steelhead is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean and subyearlings that may spend months in the estuary [Johnson et al. (2018); PNNL/NMFS (2018); and Weitkamp (2018) as cited in NMFS (2019)].

In terms of critical habitat, there are no CRS-related barriers to migration in the estuary, and there is no evidence that flows are insufficient for migration.

PROPOSED ACTION COMPONENTS SPECIFIC TO MCR STEELHEAD

The Proposed Action, continuing to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2 of this document and associated appendices, as modified by the flex spill Letter to NOAA. Reclamation is also consulting on the Columbia River mainstem effects of six irrigation projects that involve additional and separate ESA reviews.²³ This Proposed Action continues extensive operations that benefit MCR steelhead, including flow augmentation, spill, surface passage, bypasses, juvenile fish transport, and adult ladder operations. In addition, mitigation activities that have been implemented as part of previous BiOps will continue, including tributary and estuary habitat improvements; fish, avian, and pinniped predator management; and conservation and safety-net hatcheries—all described in Chapter 2 of this document. The Action Agencies will continue to coordinate with regional sovereigns and will regularly update the water management, fish passage, fish operations, and water quality plans. The Action Agencies intend to implement these actions commencing in September 2020 and continuing until a regulatory re-initiation of the consultation trigger is met.

MCR steelhead are exposed to CRS operations in the following ways:

- streamflow quantity and TDG changes from the Clearwater confluence with the Snake River and from the confluence of the Snake River with the Columbia River and to the ocean
- passage through one to four CRS dams in both the downstream and upstream migrations.

Mitigation that is part of the Propose Action includes flow augmentation; spill regimes at eight dams; cool water releases from Dworshak Reservoir during the summer migration period; juvenile fish transportation; fish facility operations at eight dams (bypasses, ladders, surface structures, outfalls, etc.); fish friendly turbines at McNary and Ice Harbor Dams; avian, fish, and pinniped predator management; tributary habitat actions linked to all MCR steelhead MPGs; and estuary habitat actions.

²³ Columbia River mainstem effects of certain Reclamation irrigation projects are included in this CRS consultation because the Columbia River hydrologic modeling incorporates all such impacts. The mainstem Columbia River impacts are included for the Yakima, Umatilla, Deschutes, and Crooked River irrigation projects. MCR steelhead do spawn and rear in some of these tributaries. The flow impacts of these projects on the mainstem Columbia River are fully integrated in discussions of flow and TDG in the parts of the migratory corridor both used by this DPS and affected by these projects.

EFFECTS OF THE ACTION ON MID-COLUMBIA RIVER STEELHEAD

The effects of the existence of the dam and reservoir system, and past operations, are part of the baseline and are not considered effects of the Proposed Action. The main effects on MCR steelhead of continuing to operate and maintain the CRS are related to downstream and upstream passage through the CRS mainstem lower Columbia River dams. This includes any delayed, or latent, mortality that may occur as a result of juvenile salmon passage at the dams. Improving juvenile and adult migration survival has been the focus of mitigation actions under past BiOps, and the benefits of these actions have been thoroughly documented [Corps et al. (2017a); Bonneville et al. (2018a), Appendix D]. These already-completed actions will continue to provide benefits in the future. The effects of the Proposed Action on this DPS and its critical habitat are described by life stage below.

Freshwater Spawning, Rearing, and Migration to the CRS

In the spawning and rearing areas, fish are not exposed to the effects of the CRS because no operations (e.g., flood risk management, irrigation, power generation) occur in these areas. Because there is no exposure to these operations that are components of the Proposed Action, there are no direct effects on individual fish in these areas.

Some individual fish of this DPS are exposed to habitat improvements through the Tributary Habitat Improvement Program as a component of the Proposed Action. MCR steelhead will benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that will result from the tributary actions. Adverse effects on individuals from actual implementation (i.e., construction) of habitat enhancement actions are mitigated through compliance with the Tributary Habitat Improvement Projects BiOp (NMFS 2013; USFWS 2013). The tributary habitat improvements are proposed for the Cascades Eastern Slope Tributaries, the John Day River, the Yakima River, and the Umatilla and Walla Walla Rivers MPGs and include streamflow protection and enhancement, improved habitat access, improved stream complexity, improved riparian habitat, and improved screening to reduce entrainment—all of which continue to improve habitat condition over baseline condition.

Juvenile Steelhead Downstream Migration Through the CRS

Juvenile MCR steelhead are exposed to the effects of CRS operations once they reach the mainstem Columbia River and as they pass through one to four dams depending on their subbasin of origin. In this migration corridor, juvenile MCR steelhead will continue to experience the deleterious impacts of a degraded environmental baseline and associated cumulative effects.

In general, the Proposed Action will continue operations and implement actions to minimize impacts and increase survival of juvenile MCR steelhead that pass through the CRS. Measures that have been implemented and will continue include flow augmentation, spill, reduction of passage through turbines (e.g., through spill, surface passage, and other juvenile bypasses), safer turbine passage, and predator management.

Operations and structural improvements have been modified by previous actions to the specific conditions and structure of each dam to reduce the proportions of juvenile fish that pass through turbines, reduce forebay passage delay, and improve overall dam passage survival (Corps et al. 2017a).

Changes in the Proposed Action compared to past operations include a flex-spill operation and changed implementation of summer spill. Because juvenile MCR steelhead do not migrate during the summer, any changes in summer spill will not affect this DPS. Changes in spring spill could result in increased juvenile passage survival for MCR steelhead that are passing through the CRS.

A more detailed analysis of the effects on MCR steelhead as a result of implementing the Proposed Action during downstream migration through the CRS is described below. The indicators that will be used to determine the effects of the Proposed Action on juvenile steelhead migration through the CRS include the following:

- Operational actions
 - survival
 - fish travel time
 - powerhouse passage proportion
 - TDG levels
 - temperature changes
 - turbidity levels
 - predation rates
- Non-operational conservation actions
 - hatcheries
 - predation management
 - tributary habitat actions
 - fish status and trend and monitoring.

Operational

Modeling results

Modeling was not conducted for MCR steelhead, and the results of modeling for UCR steelhead are used as a surrogate. The EIS COMPASS modeling results²⁴ support the anticipated results of the qualitative analysis that found that juvenile UCR (MCR) steelhead survival rates from McNary Dam to Bonneville Dam would increase from the Proposed Action compared to the current condition. The COMPASS model predicted that survival would increase less than one percentage point (Table 3-48). Travel time and powerhouse passage are predicted to remain close to the same as the current condition (Table 3-48). The COMPASS model suggests that the average exposure to TDG will increase for MO4 almost four percentage points, while TDG-related survival will increase with the Proposed Action (Table 3-48).

²⁴ The CSS model was not employed for UCR species.

Although life cycle abundance modeling was not available for UCR (MCR) steelhead, insights from both the CSS and NWFSC LCM models can be considered in discussing abundance. The NWFSC LCM relies heavily on date of arrival to estimate ocean survival, and does not consider any increases or decreases in latent/delayed mortality. As noted above, based on COMPASS modeling, travel time and juvenile survival would be similar to current condition, meaning a similar number of juveniles would arrive at the ocean with timing similar to the current condition. One could expect the result would be adult abundance to also be similar to the current condition.

Considering CSS theory, Haeseker et al. (evaluated natural-origin steelhead populations from the Entiat and Methow using CSS SR steelhead relationships, based on the CSS finding that UCR steelhead populations have similar responses to fresh water migration conditions (powerhouse passage experiences, flow) and marine conditions as their Snake River counterparts (DeHart 2019). While that analysis did not model all the MO4 measures, spill to 125% TDG at the four lower Columbia projects was estimated to produce a 3.7% SAR for the Entiat/Methow steelhead (DeHart personal communication), producing a 28% increase relative to the baseline condition used by CSS modelers (Haeseker et al. ; DeHart 2019) that may be similar to the current condition. Presumably, this increase would be a result of decreased latent mortality in the ocean.

Table 3-48. Model metrics for juvenile UCR (MCR) steelhead

Metric (Model)	NAA (2016 Ops)	MO1		MO4		Range
		Value	Change from NAA	Value	Change from NAA	
Juvenile Survival (COMPASS)	65.80%	65.60%	0.30%	66.10%	0.46%	0.50%
Juvenile Travel time (COMPASS)	6.6 days	6.7 days	1.52%	6.6 days	0	0.1 days
% Transported (COMPASS)	NA					
Powerhouse Passages (COMPASS)	2.72%	2.59%	4.78%	2.31%	-15.07%	0.41%
TDG Average Exposure (TDG Tool)	115.6% TDG	115.8% TDG	0.17%	119.8% TDG	3.63%	4.2% TDG
TDG-related Juvenile Survival	97.50%	97.40%	0.10%	93.90%	-3.69%	3.6.0%

Survival

Survival of juveniles once they enter the Columbia River is influenced by a suite of factors, such as water quality (e.g., temperature, TDG), passage at hydro projects, predators, fish travel time, etc. With few exceptions, survival studies show that measures implemented through the previous BiOps, and continued into the current Proposed Action, performed as expected and have achieved, or are very close to achieving, the 2008 BiOp juvenile dam passage survival objective of 96 percent for juvenile

steelhead (NMFS 2017e; p. 16). For example, for juvenile steelhead (no stock-specific estimates are available), dam passage survival has ranged from 96.5 percent to 97.6 percent at Bonneville Dam, and ranged from 95.3–99.5, 97.4–98.7, 96.9–99.1 percent, at The Dalles, John Day, and McNary Dams, respectively (Bonneville et al. 2017).

While turbine survival is generally lower than spillway survival, bypass and sluiceway survival can be close to, equal to, or often greater than spillway survival in terms of direct dam survival. The COMPASS model relies on juvenile route survival estimates, and predicts the increase in spill (flexible spill up to 125 percent TDG) will result in an increase in juvenile SR steelhead (steelhead are used as a surrogate for MCR steelhead because no modeling was performed for MCR steelhead) reach survival when passing eight dams. Survival improvement for MCR steelhead may be less because they pass fewer dams. It is important to note that because higher spill levels result in unbalanced energy and degraded tailrace conditions, juvenile survival rates could be lower than COMPASS predicts as a result of extended tailrace delay and the potential for predation at some projects, but most predictions are for increased survival.

As reported earlier (Table 3-2), average annual reach survival of natural- and hatchery-origin steelhead from the Snake River (used as a surrogate for MCR steelhead) from McNary Dam to Bonneville Dam (235 km) increased from 0.57 (1997–2008; no estimates for this reach in 2004 and 2005) to 0.79 (2009–2018) (Widener et al. 2019). Implementation of the Proposed Action is expected to maintain or improve survival of MCR steelhead migrating through the system and reduce any potential latent/delayed mortality after they pass Bonneville Dam. The COMPASS model estimates that survival could increase juvenile survival from McNary Dam to Bonneville Dam by less than one percent higher than the 2016 operation.

Mainstem CR Fish Travel Time

Under the flex spill plan, spring spill operation will spill to state water quality limits for 16 hours per day (anticipate 125 percent starting in 2020), and performance spill for 8 hours per day. The performance spill patterns and amounts were developed using a combination of 2008 FCRPS BiOp-prescribed spill and performance standard testing guidelines, and gas cap spill uses spill up to state water quality standards with some restrictions for erosion concerns and powerhouse minimums. The main effect of the higher spill are a decrease in forebay delay, an increase in spill passage efficiency, and a hypothesized (reduction in) latent mortality (NMFS 2019). This results in shorter forebay residence times. Modeling results for SR steelhead, which serves as a surrogate for MCR steelhead in the lower Columbia River, estimates that the fish travel time from McNary Dam to Bonneville Dam will be slightly reduced. Additional flow through the spill bays will likely draw a greater proportion of juvenile steelhead migrants from the powerhouse routes (turbine and bypass) and surface passage routes (surface weir and sluiceway). Model estimates suggest that implementation of the Proposed Action could decrease juvenile travel time by approximately 8-14% percent. Decreasing smolt travel time with higher levels of spill through the CRS can provide a survival advantage due to reducing exposure time to predators, and fostering a more normative synchrony between the physiological process of smolt transformation and the timing of seawater entry.

Powerhouse Passage Proportion

In addition to increasing spill in the spring, the Action Agencies propose to modify spillway weirs and turbines at John Day Dam. These actions are anticipated to increase survival of juvenile fish that pass through those routes. In addition, increasing the proportion of water discharged as spill directs a higher fraction of migrants away from the powerhouse and toward the less hazardous spillway. This reduces smolt encounters with turbines and screened bypass systems, both of which have been implicated in contributing to latent mortality as expressed in the marine environment. It is also possible that reduction in powerhouse encounters results in reductions in latent mortality, thereby leading to increased survival during later life stage development in the estuary and marine environments. The COMPASS model predicts a potential slight decrease (< 1%) in powerhouse encounters for juvenile UCR (MCR) steelhead as a result of these actions.

Total Dissolved Gas

Spill at CRS dams can cause downstream waters to become supersaturated with dissolved atmospheric gases. This may occur during periods of high flows (involuntary spill) or purposely for set periods of time as a result of the Proposed Action (flex spill). Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids that may result in injury or death. Survival of juvenile salmonids can be reduced when TDG levels exceed lethal limits and fish are not able to compensate by swimming into deeper water (Beeman and Maule 2006).

Biological monitoring within the CRS shows that the incidence of GBT in migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 125 percent of saturation (Antcliffe et al. 2002; Backman et al. 2002; NMFS 2019). When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. McGrath et al. (2006) determined that newer research supports previous research that indicated short-term exposure to up to 120 percent TDG does not produce significant effects on juvenile (or adult) salmonids when compensating water depths are available (Beeman and Maule 2006; NMFS 2019). Therefore, it is anticipated that any increase in TDG as a result of implementing the flexible spill operation will result in negligible increases in GBT to outmigrating juvenile MCR steelhead through the CRS.

Temperature Changes

Temperature changes can cause stress and mortality to MCR steelhead. Temperature influences growth and feeding rates, metabolism, development, migration timing, and the availability of food. In addition, temperature plays a role in predator fish behavior, which also affects juvenile salmonid survival.

Current temperature conditions are different from historical conditions as a result of a suite of anthropogenic activities (described in the status of the species section). The Proposed Action is not anticipated to change the current temperature regime in the river during the time that MCR steelhead juveniles are outmigrating through the CRS. Therefore, it is anticipated that temperature changes attributable to the Proposed Action are likely indistinguishable from current conditions and will result in negligible consequences to outmigrating juvenile MCR steelhead.

Turbidity Levels

Development of the CRS (and other non-federal dams) has reduced sediment transport from historical levels, and subsequently reduced turbidity by having suspended particles in the water fall out when the water enters a slower moving reservoir. Lowered turbidity levels may increase the susceptibility of MCR steelhead to avian and piscivorous predators because of increased visibility in the water column. Avian predation is most likely to occur in the tailrace of the dams, while piscivorous predation may occur in both the forebay and the tailrace. Implementing the Proposed Action is unlikely to result in changes in the amount of suspended solids (and resulting turbidity) in the water column through the CRS. However, while outmigrating juvenile MCR steelhead will continue to experience a less turbid system as a result of past actions, the Proposed Action includes measures to address these impacts in the vicinity of the dams, as described in the next section (predation).

Predation

A variety of bird and fish predators consume juvenile MCR steelhead on their migration from tributary rearing areas to the ocean (cross reference predation section or appendix). Existing conditions create habitat that is more ideal for both native and non-native predatory fish. Outmigrating juvenile MCR steelhead encounter these predatory fish as they pass through the reservoirs and tailraces of the CRS. Implementing the Proposed Action will not change conditions in a manner that will substantially modify the distribution or abundance of predatory piscivorous fish in the CRS reservoirs; thus, outmigrating MCR steelhead are anticipated to continue to be exposed to predation as they migrate through the CRS. Fish in the tailraces may be particularly susceptible to predation based on their passage route through the dam, because of potential disorientation from the passage experience. However, the flex spill program may help reduce predation in CRS dam tailraces by increasing the turbulence downstream of the dams, making it more difficult for birds to locate and prey upon juvenile salmonids. As described above, lower turbidity levels may influence the effectiveness of visual predators.

Efforts to minimize predation by birds and pikeminnow will continue with the Proposed Action. In 1990, the Action Agencies began a program to reduce predation by northern pikeminnow by removal at the dams and a sport reward program that pays anglers for pikeminnow removed (see Northern Pikeminnow Management Program below). Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to rates before the start of the program and estimated a median reduction of 30 percent. Avian dissuasion actions at the dams (e.g., wires, sprinklers, etc.) will also continue with implementation of the Proposed Action. Collectively, these efforts are intended to reduce predation rates on outmigrating juvenile MCR steelhead through the CRS.

Non-Operational

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs and there are currently four fall Chinook hatchery programs in the Snake River Basin. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to operation of federal and non-federal dams, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin

salmon Chinook salmon and their habitat depends on the design of hatchery programs (which have existing consultation), the condition of the habitat, and the status of the species, among other factors.

Most hatchery programs are run by the state in which they occur or by tribes. It is anticipated that most of the current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue. Current hatchery programs will continue to be studied and management agencies will make recommendations to reduce potential effects if they occur.

Predation Management

Predation on salmon and steelhead in the Columbia River Basin affects species survival and viability. Birds and native and non-native fish prey on juveniles as they pass through the hydrosystem. Direct predation occurs when hatchery-origin fish eat natural-origin fish; indirect predation occurs when predation from other sources increases as a result of the increased abundance of juvenile salmon and steelhead from hatchery releases.

Native northern pikeminnow (*Ptychocheilus oregonensis*) and introduced species such as smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), and channel catfish (*Ictalurus punctatus*) can be substantial predators of juvenile salmonids on their migration to the ocean. Native bird species, such as Caspian terns (*Hydroprogne caspia*), double-crested cormorants (*Phalacrocorax auratus*), American white pelicans (*Pelecanus erythrorhynchos*), California gulls (*Larus californicus*), and ring-billed gulls (*L. delawarensis*) that nest in large colonies close to the Columbia River are also known to consume large numbers of salmonids.

Avian

Based on PIT-tag recoveries at East Sand Island (near the mouth of the Columbia River), average annual tern and cormorant predation rates for MCR steelhead were about 14.9 and 8.3 percent, respectively, before efforts to manage the size and nesting location of these colonies (Evans et al. 2018). Previous management actions implemented by the Action Agencies to relocate various colonies has had some positive effect by reducing the predation rate on MCR steelhead to just over 9 percent (Evans et al. 2018). Efforts to minimize predation by birds will continue with the Proposed Action. The flex spill program may also decrease predation in CRS dam tailraces by increasing the turbulence downstream of the dams, making it more difficult for birds to locate and prey upon juvenile salmonids.

The Action Agencies have developed various plans to help minimize predation by birds. In 2005, the Caspian tern management plan was approved (USFWS 2005), and in 2014, the Inland Avian Predation Management Plan (IAPMP) began (Corps 2014a). These plans manage for avian predation on juvenile salmonids as they migrate to the ocean by redistributing bird nesting colonies in the estuary (USFWS 2005), or inland (Corps 2014a) to other nesting sites in the western U.S. Continued implementation of these plans under the Proposed Action will continue to minimize bird predation of juvenile salmonids, including MCR steelhead.

Piscivorous Fish

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River. In 1990, the Action Agencies began The Northern Pikeminnow Management Program (NPMP) to reduce

predation by northern pikeminnow by removing fish at the dams, and initiating a sport reward program that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake Rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to rates before the start of the program and estimated a median reduction of 30 percent.

Non-native walleye and smallmouth bass have been shown to have substantial predation effects on juvenile salmonids. For example, (Beamesderfer and Nigro 1989) estimated that walleye annually consumed an average of 400,000 salmonids, or up to 2 percent of the salmonid run from 1983–1986. The abundance of walleye in the lower Columbia River appears to be highly variable, but losses of juveniles and smolts to walleye was estimated to number up to 2 million fish per year, which compares to 4 million for pikeminnow (Tinus and Beamesderfer 1994). In the Yakima River, smallmouth bass appear to have a preference for fall Chinook salmon, which make up to 47 percent of their diet in May (Fritts and Pearsons 2004). In the Columbia River near Richland, WA, salmonids made up nearly 60 percent of smallmouth diets (Tabor et al. 1993).

All predator management programs will continue under the Proposed Action.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on MCR steelhead. These are associated with the capturing and handling of fish. Research, monitoring, and evaluation activities occur throughout the Columbia River Basin as part of managing the CRS. In general, the RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, AEMR (action-effectiveness monitoring and research), critical uncertainty research, and data management. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. Some RM&E actions also involve sacrificial sampling of fish. NOAA Fisheries (2019) estimated the number of juvenile MCR steelhead that have been handled each year during the implementation of RM&E under the 2008 BiOp and determined that the average handling and mortality were not substantial. They concluded that

... slightly more than one percent of the wild juvenile production was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to one percent of these juveniles (in this case, <0.02 percent of the wild production) died after they were released due to effects of handling. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of FCRPS operations, including modifications to facilities, operations, and mitigation actions.

It is reasonable to assume that the estimates of annual take on juvenile MCR steelhead will continue at approximately the same level in the future because the Proposed Action will still fund much of the RM&E that is occurring in the CRS.

Juvenile Steelhead Estuary Migration and Rearing, Including the Plume

Estuarine and nearshore ecosystems provide habitat for juvenile steelhead to forage and avoid predators. Most juvenile steelhead move through the estuary in 1 or 2 days, and survival in this reach appears to be high (Daly et al. 2014) excluding mortality associated with avian predation. The existence

and operations of the CRS has led to long-standing changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, any direct impacts on these parameters due to the Proposed Action of continuing CRS management are expected to be minor.

There is an apparent relationship between plume characteristics at the time of ocean entry and SARs for steelhead. Jacobson et al. (2012) found that steelhead SARs increased with the size and offshore distance of the plume under favorable large-scale ocean conditions, but did not change when ocean conditions were poor (Jacobson et al. 2012). It is not likely this relationship will be affected by the Proposed Action.

Avian predation continues to be a serious issue in the estuary and juvenile steelhead appear to be targeted to a larger degree than other species (see Section 3.2.1.4). Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary as part of the Proposed Action will benefit this DPS by reducing the number of individuals of this DPS eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1].

The indicators used below to assess the effects of the Proposed Action on juvenile MCR steelhead migration through the estuary and plume are categorized as operational (survival, fish travel time, TDG, temperature, turbidity, and predation) and non-operational (predation management, habitat actions and fish status and trend monitoring). Using these indicators, analyses of effects on MCR steelhead during downstream migration through the CRS as a result of implementing the Proposed Action are described next.

Operational

Survival

Fish use in the estuary likely affects their subsequent survival in the ocean. Monitoring and research suggests that fish size and the time of ocean entry, which are in part due to conditions in the estuary, can affect salmon growth and survival in the ocean (Chittaro et al. 2018; Johnson et al. 2018). Habitat enhancements that improve capacity (e.g., prey productivity) may lead to the increased growth and improved condition of migrating juvenile salmonids in the estuary. The improved condition of fish in the estuary can contribute to increasing the likelihood of their survival into the ocean.

Fish Travel Time

Proposed changes in water management are not expected to substantially increase flows downstream of Bonneville Dam, and therefore, the factors that currently influence fish travel time to the estuary are not likely to change. The travel time of juvenile MCR steelhead that pass Bonneville Dam is not likely to change from the current condition under the Proposed Action.

Total Dissolved Gas

As mentioned previously, GBT was historically a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into

saturation (NMFS 2019). Elevated TDG levels during periods of increased spill extend downstream until attenuated at RM 110.

Temperature

As mentioned above, very little change in temperature is expected under the Proposed Action upstream of Bonneville Dam. The same is anticipated to be true for the reach from Bonneville Dam to the estuary.

Turbidity

As mentioned previously, it is not anticipated that the Proposed Action will have much of an effect on turbidity in the CRS, including the section of the mainstem river from Bonneville Dam to the estuary.

Predation Rates

The Proposed Action is not anticipated to have any effect on the rate of predation of juvenile salmonids in the Columbia River, except potentially in the tailraces during higher spill periods (reducing predation; see above). Continuing to implement the Caspian tern and cormorant management plans and the NPMP will result in negligible changes in predation, but will prevent the impacts from “backsliding” to levels that were occurring prior to the Action Agencies’ implementation of these plans.

Non-Operational

Predation Management

The Proposed Action will continue to implement the various predator programs that are currently being implemented in the estuary and mainstem Columbia River. As such, the Proposed Action will not result in meaningful changes in the predation rate, although it is anticipated that rates may decrease as the programs evolve and more knowledge is gained.

Hatcheries

As discussed previously, the effects of hatchery fish on natural-origin fish in the Columbia River estuary and the Pacific Ocean is still poorly understood, and available knowledge and research abilities are insufficient to discern any important role or contribution of hatchery fish in density-dependent interactions affecting salmon and steelhead growth and survival in the mainstem Columbia River, the Columbia River estuary, and the Pacific Ocean. As discussed above, NOAA Fisheries (2016f) concluded that

[the] influence of density-dependent interactions on the growth and survival of salmon and steelhead is likely small compared with the effects of large-scale and regional environmental conditions. While there is evidence that large-scale hatchery production can affect salmon survival at sea, the degree of effect or level of influence is not yet well understood or predictable. The same thing is true for mainstem rivers and estuaries.

Estuary Habitat Actions

Since the late 1800s, a high percentage of habitats in the LCRE have been lost through flow alterations and diking. As mitigation for the impacts of the CRS, a restoration effort (the CEERP) begun in earnest in 2000 involved removing barriers on the river floodplain in rural areas of Washington and Oregon (Diefenderfer et al. 2013). Specifically, the CEERP's primary goals are to restore wetland and estuarine habitats; restore or improve hydrologic connectivity between river flows and those restored habitats; and restore hydrologic and estuarine processes (flow patterns, localized flood regimes, sediment accretion, erosion, and floodplain function). Specific actions to achieve this could include protection of existing habitats, using dredged materials to better shape estuarine landforms, channel excavation, floodplain re-contouring, removal or relocation of water control structures (e.g., levees, dikes, tide gates, drainage structures), and invasive species removal (Bonneville and Corps 2016).

Diefenderfer et al. (2013) evaluated whether juvenile fish that use the estuary were responding favorably to the restoration actions. They used a "line of evidence" approach and concluded the following:

- Hydrologic reconnections restore access for fish to move into a site to find prey produced there. Reconnections also restore the potential for the flux of prey from the site to the mainstem river, where data show that they are consumed by salmon.
- Restoration supports increased juvenile salmon growth and enhanced fitness (condition), thereby potentially improving survival rates during the early ocean stage.
- Ongoing cumulative impacts from urbanization and decreased forest cover, although outside of the control of the CEERP, could impair the development of resilient ecosystems on the river floodplain.
- The habitat restoration activities in the LCRE are likely having a cumulative beneficial effect on juvenile salmon, including interior basin salmon.

Implementation of the Proposed Action will continue habitat restoration efforts that are benefiting juvenile salmonids. Project effectiveness is expected to increase over time as they mature and new ones are implemented.

Fish Status and Trend Monitoring

One aspect of the CEERP is to monitor the effectiveness of restoration actions and conduct research to address critical uncertainties. Adaptive management is used to guide program goals and actions (Johnson et al. 2018), and RM&E will continue under the Proposed Action. As illustrated above, the CEERP is benefiting salmonids, both in the juvenile and adult life-history stages.

Ocean Rearing

MCR steelhead typically spend 1 to 2 years maturing in the ocean. During ocean residence, the mortality of anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2014a; U.S. v. Oregon 2018; NMFS 2019). Of the factors that influence ocean productivity, which have been linked to salmonid growth and survival, the most influential is the Pacific Decadal Oscillation (PDO). However, other processes, such as the Northern California Current

(NCC), the North Pacific Gyre Oscillation (NPGO), the El Niño Southern Oscillation (ENSO), climate change, and ocean acidification (NMFS 2019) also contribute to ocean productivity. All these factors will affect survival, directly or indirectly, because of their deleterious impacts on marine food webs.

In addition to these climatic factors that can influence marine survival of MCR steelhead, there is a small potential for bycatch effects associated with ocean fisheries for other salmonid species. However, bycatch of MCR steelhead in ocean fisheries numbers in the low hundreds of fish per year to very rare (NMFS 2019).

The Proposed Action will have no effect on the marine habitats used by MCR steelhead for growth and maturing because there are no CRS operations that affect this area.

Adult Steelhead Migration to Bonneville Dam

While no indices of migration rate from coastal waters to Bonneville Dam exist for MCR steelhead, NMFS reported that SR spring/summer Chinook, on average, took 18.1 days in 2011 and 15.4 days in 2012 to navigate that reach of the river (NMFS 2014a). CRS operations generally result in negligible changes in flow and TDG levels in the estuary. It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River by the distance from the facilities and the streamflows from lower river tributaries like the Willamette River. The Proposed Action causes no adult migration barriers for MCR steelhead adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration in this reach, an effect not caused by CRS operations. Thus, the Proposed Action is likely to have negligible effects on MCR steelhead adult migration from the ocean to the CRS.

A more detailed analysis of the effects on adult MCR steelhead returning to the Columbia River and migrating up to the system as a result of implementing the Proposed Action is described below.

Operational

Travel Time

The Proposed Action is not expected to alter the migration rate of adult MCR steelhead in the lower Columbia River downstream from Bonneville Dam. While the Proposed Action will likely result in negligible flow reductions and water particle velocity at the time adult steelhead will be entering and migrating through the lower Columbia River, this reduction is not expected to result in a measurable increase or decrease in migration rate.

Total Dissolved Gas

The Proposed Action includes a flexible spill component, which during spring spill operations will result in spill at CRS projects to a level where the state water quality limit for TDG is met 16 hours per day, with a performance spill component totaling 8 hours per day. As such, TDG levels will reach 120 percent

of saturation during the 16-hour block, and a lesser amount during the performance spill component. Furthermore, it is anticipated that the gas cap of 120 percent for the 16-hour block will increase to 125 percent in 2020. Based on these operations, it is anticipated that adult MCR steelhead will be potentially exposed to slightly elevated TDG levels.

Elevated levels of TDG can increase the likelihood of GBT in adult and juvenile salmonids, which can injure or kill afflicted individuals. To offset the extent of gas supersaturation at CRS projects, the Corps has installed gas abatement devices within the spillways to reduce TDG levels.

Severe GBT is not typically observed when TDG levels do not exceed state water quality standards of 120 percent. Furthermore, GBT in juvenile salmonids remains below 2 percent when TDG levels do not exceed 120 percent, and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). In 2018, the Action Agencies operated spill at CRS projects to reach but not exceed 120 percent TDG. At those levels, reach survival and observed GBT did not reach measurable levels (NMFS 2019).

Based on the attenuating effect of the distance downstream of the system, and influence of tributary streamflow, the Proposed Action is not expected to have measurable effects on MCR steelhead adults downstream from Bonneville Dam.

Temperature

Poor water quality, which includes increased water temperature, can lead to stress in adult MCR steelhead, which in turn can lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth and osmoregulation). Furthermore, elevated water temperatures can affect salmonid distribution, behavior, migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect the survival of adult MCR steelhead (NMFS 2019).

Major factors that influence water temperatures within the Columbia River Basin, including downstream from Bonneville Dam, include natural variations in weather and river flow; the existence of the hydroelectric system; increased tributary temperatures due to irrigation, grazing, and logging; urbanization and population growth; and projected increased air temperature due to climate change. The extent that these factors influence water temperatures downstream from Bonneville Dam is expected to increase as urbanization and population growth increase, and the effects of climate change become more pronounced.

Because actions associated with the Proposed Action will not result in elevated water temperatures downstream from Bonneville Dam, the effects of the Proposed Action are not expected to negatively affect adult MCR steelhead within this reach.

Turbidity

Development of the hydroelectric system has altered the extent of sediment transport downstream through the Columbia River, including the reach downstream from Bonneville Dam. It is estimated that the total sediment discharge into the estuary and the Columbia River plume is approximately one-third of pre-hydrosystem levels, which has altered the development of habitats along the margins of the river (NMFS 2019).

Because actions associated with the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam, the Proposed Action is not expected to negatively affect adult MCR steelhead in this reach.

Non-Operational

Predation

For upstream migrating MCR steelhead, the primary factor affecting their survival to Bonneville Dam is pinniped predation. The existence of Bonneville Dam, which is part of the environmental baseline, likely causes pinnipeds to congregate downstream from that project. However, if Bonneville Dam were not present, the pinnipeds would likely congregate at Cascade Falls or other upstream falls, much like they do at Willamette Falls. Estimates of pinniped predation downstream of Bonneville Dam are not available for adult MCR steelhead; however, salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019).

In a study assessing pinniped predation on adult salmonids and other species, Tidwell et al. (2018) estimated a consumption rate of 1.54 percent for all steelhead collectively and concluded that the estimate is a reasonable rate of consumption of MCR steelhead. As noted in the 2019 BiOp, average pinniped impacts on summer migrating adult MCR steelhead are likely relatively small because pinniped counts are generally low in July and August (when most MCR steelhead pass Bonneville Dam), and MCR steelhead are mixed with relatively abundant fall Chinook salmon migrating in September and October (NMFS 2019).

Measures intended to reduce predation on adult salmonids such as hazing, predator removal, and the continued use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates) will continue. Furthermore, if pinnipeds are observed in the tailrace of The Dalles Dam, hazing efforts may be implemented at that project's ladder entrances. No components of the Proposed Action are expected to result in a change associated with pinniped predation.

Adult Steelhead Migration Through CRS Dams

Adult MCR steelhead use fish ladders to swim past one to four CRS dams on their way to the spawning grounds. Populations from the Cascades Eastern Slope Tributaries MPG pass one to two CRS dams during their upstream migration, depending on the stream of origin. Populations originating from the John Day and Umatilla River Basins migrate through three mainstem dams and reservoirs, and populations originating from the Yakima and Walla Walla Rivers migrate through four mainstem dams and reservoirs.

Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life stages such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

As reported earlier, adult MCR steelhead have relatively high conversion rates when passing the lower Columbia River CRS dams (NMFS 2019). NOAA Fisheries (2019) used conversion rates of PIT-tagged SR

steelhead migrating through the CRS as a surrogate for MCR steelhead, and determined that the 5-year rolling average of 88.9 percent survival from Bonneville to McNary Dam, and 76.5 percent from Bonneville to Lower Granite Dam, served as reasonable estimates of survival through the CRS.

A more detailed analysis of effects on adult MCR steelhead migrating upstream through the CRS as a result of implementing the Proposed Action is described below.

Operational

As discussed previously, the Proposed Action includes a flexible spill component, which during spring spill operations will result in spill at CRS projects to a level at which the state water quality limit for TDG is met 16 hours per day, with a performance spill component totaling 8 hours per day. As such, TDG levels will reach 120 percent of saturation during the 16-hour block, and a lesser amount during the performance spill component. Performance spill standards vary by project but are based either on a volume of water passing via the spillway (i.e., kcfs), or the proportion of the overall river flow that is spilled. The flex spill program will occur April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects. Furthermore, it is anticipated that the gas cap of 120 percent for the 16-hour block will increase to 125 percent in 2020.

Other components of the Proposed Action include structural measures such as modifying the Bonneville ladder serpentine weir and installing ladder pumps to provide deeper, cooler water into the fish ladders at Lower Monumental and Ice Harbor Dams; those measures are intended to reduce delay within the fishways. Also, the Proposed Action includes the flexibility to increase the reservoir drawdown within the John Day Reservoir and lower Snake River reservoirs by 0.5 feet. Collectively, these measures have the potential to affect MCR steelhead.

Modeling results

No life cycle modeling was completed for adult UCR steelhead. NWFSC LCMs for steelhead are still in development and not available for this analysis and CSS LCMs modeling of alternatives were not provided for Upper Columbia species. However, insights from both the CSS and NWFSC LCM models can be considered in discussing abundance of returning adults.

The NWFSC LCM relies heavily on date of arrival to estimate ocean survival, and does not consider any increases or decreases in latent mortality. Based on COMPASS modeling, travel time and juvenile survival of UCR (MCR) steelhead would be similar to current condition, meaning a similar number of juveniles would arrive at the ocean with timing similar to current condition. It is reasonable to assume that UCR (MCR) steelhead adult abundance would also be similar to the current condition.

Total Dissolved Gas

Populations of adult MCR steelhead enter the Columbia River estuary and pass over Bonneville Dam as early as May, but most migrants are observed from June 1 through the end of October, and peak migration occurs in early August (Keefer et al. 2016). Because of the increased TDG levels associated with the flex spill component of the Proposed Action, earlier migrating adult MCR steelhead will likely be exposed to elevated TDG levels.

As described in the previous section, GBT is not typically observed when TDG levels do not exceed the state water quality standard of 120 percent, and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). It should be noted, however, that most adult MCR steelhead arrive at Bonneville Dam beginning around the first part of June and their numbers peak in early August. Therefore, the majority of adult MCR steelhead will not be exposed to the elevated levels of TDG associated with the Proposed Action. Based on the limited observations of GBT at expected TDG levels associated with the Proposed Action and given the migrational timing of adult MCR steelhead within the CRS, the Proposed Action is not expected to result in an elevated risk of GBT to MCR steelhead.

Fallback

Adult MCR steelhead fallback at dams either while migrating upstream through the CRS, after they overshoot their natal stream and reside for some time in an upstream reservoir, or as they migrate downstream as kelts. Typical fallback occurs after an individual ascends a fishway and then passes back downstream from the project in a relatively short period of time. This activity is often associated with higher spill levels at the project. Fish that overshoot their natal stream appear to do so when water temperatures within the mainstem Columbia River exceed 64°F. When water temperatures exceed this level, adult MCR steelhead seek out cold water refugia in cool tributaries such as the Little White Salmon, White Salmon, or Deschutes Rivers, or in deep water areas in the Snake River (NMFS 2019). Based on PIT-tag detections of adult MCR steelhead, it is estimated that 12.3 percent of the fish tagged at Bonneville Dam are also detected at Ice Harbor Dam, and 4.4 percent at Lower Granite Dam (NMFS 2019).

For adult MCR steelhead, mean annual fallback rates at lower Columbia River dams is about 6 to 9 percent (Keefer et al. 2016). Furthermore, Keefer et al. (2007) found that winter fallback-related mortality is not distributed evenly among populations for MCR steelhead, and overshoot-related winter fallback mortality may be relatively high at dams closest to home tributaries, such as at John Day Dam for Deschutes River fish or at McNary Dam for John Day River fish. However, survival to tributaries by adult steelhead overwintering within the CRS is approximately 82–92 percent (Keefer et al. 2016).

The Proposed Action, specifically the flex spill component, will have the potential to increase the rate of fallback at CRS dams. With increased spill, it is likely more of the fish that fallback at a given project will do so through the spillway, or some surface-oriented passage route. However, spill at lower Columbia River dams will terminate on June 15, and on June 20 at Snake River dams. For fish that do fallback during the flex spill program, and specifically through the spillway or a surface structure, survival of that fallback event is relatively high. At Bonneville Dam, direct survival tests show that for fish passing downstream of the dam via the ice/trash sluiceway and the corner collector survived at a rate greater than 98 percent (after 48 hours). At McNary Dam, direct survival was estimated to be approximately 98 percent through the TSW (temporary spill weir). Conversely, direct survival through the McNary turbines was estimated to be approximately 91 percent (Keefer et al. 2016). For later migrating fish (i.e., those that ascend the CRS after termination of the flex spill program), the rate of fallback is not expected to change.

Temperature

As described previously, poor water quality, which includes increased water temperature, can lead to stress in adult MCR steelhead, which in turn can lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth and osmoregulation). Furthermore, elevated water temperatures can affect salmonid distribution, behavior, migration speed, timing of river entry, and susceptibility to predation. All these factors can negatively affect survival of adult MCR steelhead (NMFS 2019).

Major factors that influence water temperatures in the Columbia River Basin include natural variations in weather and river flow; the existence of the hydroelectric system; increased tributary temperatures due to irrigation, grazing, and logging; urbanization and population growth; and projected increase in air temperature due to climate change. The extent that these variables influence water temperatures within the CRS is expected to increase as urbanization and population growth increase, and the effects of climate change become more pronounced. However, implementation of the Proposed Action is not expected to alter water temperatures within the CRS.

Because actions associated with the Proposed Action will not result in elevated water temperatures within the CRS, the Proposed Action is not expected to affect adult MCR steelhead within this reach.

Turbidity

Development of the hydroelectric system has altered the extent of sediment transport downstream through the Columbia River, including within the CRS. While other anthropogenic activities such as agriculture, irrigation, mining, logging, road building, etc. have increased sediment into the mainstem Columbia River, both federal and non-federal dams act as a sediment sink, trapping sediments upstream from dams. These activities and conditions are expected to continue at the current rate.

Because actions associated with the Proposed Action are not expected to result in changes in sediment load within the CRS, the Proposed Action is not expected to affect adult MCR steelhead within this reach.

Non-Operational

Predation

Predation on adult MCR steelhead within the CRS is rare, and pinnipeds are the primary predators. While pinniped predation commonly occurs within the tailrace of Bonneville Dam downstream to the Pacific Ocean, pinniped observations upstream from Bonneville Dam are rare.

Measures intended to reduce predation on adult salmonids such as hazing, predator removal, and use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates) will continue. Furthermore, if pinnipeds are observed in the tailrace of The Dalles Dam, hazing efforts may be implemented at that project's ladder entrances. No components of the Proposed Action are expected to result in a change associated with pinniped predation.

In addition, activities conducted under predator fish management programs, like the NPMP, could potentially affect MCR steelhead by the accidental hooking of adults at the dams and throughout the hydrosystem while fishing for northern pikeminnow, or potentially being bycatch while the number of pikeminnow are being indexed through electroshocking. However, the incidental catch of adult steelhead while angling (at dams and throughout the hydrosystem), and during removal efforts using electrofishing have remained below limits for the NPMP (Williams et al. 2019).

Adult Steelhead Migration Upstream of the CRS to the Spawning Areas

Operational

After migrating upstream through the CRS, adult MCR steelhead begin to migrate to their natal streams. Once they enter those tributaries, they are no longer exposed to the operation and related effects of the CRS.

As described previously, within the Mid-Columbia River tributaries that support the spawning and rearing of MCR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (1) impaired fish passage (including tributary dams); (2) reduced stream complexity and channel structure; (3) an excess of fine sediments; (4) elevated summer water temperature; (5) diminished streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

Non-operational

Within MCR steelhead tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this DPS. A more detailed description of the effects of those actions is provided below.

Hatchery Programs

A variety of MCR steelhead artificial production programs are funded by the Action Agencies, and others are funded by other sources. Hatchery programs may provide short-term benefits such as increasing abundance, especially during periods of low natural abundance, and can also help preserve genetic integrity of a population until other limiting factors can be resolved. However, long-term implementation of hatchery programs can also negatively affect populations (NMFS 2019).

For MCR steelhead, straying can be a significant factor. The Mid-Columbia Expert Panel ranked the straying of out-of-DPS hatchery fish into the Eastside and Westside Deschutes and lower John Day populations as a primary concern and straying into the Umatilla and Walla Walla populations as a secondary concern. Out-of-DPS strays may negatively affect the genetic traits and productivity of natural populations through interbreeding and competition for suitable spawning areas (NMFS 2019).

The Action Agencies have been a funding source for the Kelt Reconditioning and Reproductive Success Evaluation Project on the Yakima River for MCR steelhead. Results derived from those research efforts demonstrate that reconditioned kelts exhibited a higher return rate of repeat spawners than naturally returning Yakima kelts [11.5–17.6 percent compared to 2.7 percent, respectively (NMFS 2019)].

The hatchery programs described above will be implemented into the future without alteration due to the Proposed Action. As such, no change in MCR steelhead is anticipated due to hatchery operations.

Tributary Habitat Actions

Nearly all of the historical habitat for MCR steelhead has been extensively modified by anthropogenic actions. As described previously, many factors limit the viability of this DPS. In response to these alterations, many habitat measures have been implemented specifically to benefit MCR steelhead by federal, state, local, and private entities, including the Action Agencies. Since 2007, the Action Agencies have

- protected 94,136 acre-feet of water through efficiency improvements and water purchase/lease projects
- protected 42,824 acres through land purchases or conservation easements
- treated 7,489 acres to improve riparian habitat
- enhanced or made accessible 1,858 miles of habitat by providing passage or removing barriers
- improved 158 miles of stream complexity
- protected 1,139 miles of habitat through land purchases or easements
- Installed or addressed 265 screens.

Based on the best available science, NMFS has concluded that these actions have improved, and will continue to improve, habitat for MCR steelhead as the projects mature. Furthermore, fish population abundance, productivity, spatial structure, and diversity should respond positively (NMFS 2019).

Fish Status and Trend Monitoring

It is anticipated that the Action Agencies' RM&E program will continue at current or perhaps somewhat reduced levels of effort. As such, the level of injury and mortality associated primarily with the capture and handling of MCR steelhead is expected to be maintained at current or slightly decreased levels. Those impacts are summarized in the 2019 BiOp (NMFS 2019) and include the following:

- Projected estimates of MCR steelhead handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) zero hatchery or wild adults handled, and (2) zero hatchery or wild adults killed.
- Projected estimates of MCR steelhead handling and mortality during activities associated with fish status monitoring: (1) 100 hatchery and 1,200 wild adults handled, and (2) one hatchery and 12 wild adults killed.

- Projected estimates of MCR steelhead handling and mortality for all other RM&E programs: (1) 720 hatchery and 200 wild adults handled, and (2) 7 hatchery and 2 wild adults killed.

Implementation of the Proposed Action will not alter fish monitoring programs associated with MCR steelhead, and as such, no effects of these actions are anticipated for this DPS.

Adult Steelhead Downstream Passage (Kelts)

Anadromous steelhead in the Columbia River have multiple life history strategies including iteroparity. Iteroparity involves the downstream migration of post spawned steelhead (kelts) that return to the ocean or estuary environments for a period of time before spawning again. Kelt returns can be affected by the extreme energetic demands of spawning and iteroparity, harvest (which may affect spawn timing and location), and the Columbia Basin Hydrosystem (Colotelo et al. 2014). Most studies of adult survival carried out at Columbia River dams have used overwintering summer run steelhead (Khan et al. 2009; Ham et al. 2012a, b; Khan et al. 2013); hence, CRS related mortality specifically for downstream migrating kelts is not as well-known at this time. The Corps conducted a direct survival test of adult steelhead passing through McNary dam in 2014; mean survival rates were 97.7% through the spillway weir route, and 90.7% via the turbine route for overwintering adults presumed to be in good condition (Normandeau 2014). As part of a two year study, Colotelo et al. (2013) estimated that 45% of SR steelhead kelts survived from the Lower Granite forebay to the Bonneville dam face (RM 234) and 41 percent of the lower Columbia River (LCR) (RM156), respectively. An estimated 67% of kelts survived from the McNary forebay to the Bonneville Dam face (Colotelo et al. 2013). River conditions were warmer with lower flow in the second year of the study in 2013; mean survival rates between Lower Granite Forebay and the lower Columbia River were somewhat lower (approximately 27%) and rates of travel were slower (Colotelo et al. 2014). In both years, smaller sized steelhead had better rates of survival; it was uncertain whether this resulted from a higher rate of injuries to larger bodied steelhead in dam passage routes, or whether larger fish were in poorer post-spawn condition.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

The effects of the Proposed Action on critical habitat are discussed in this section. Effects on critical habitat were assessed based on the elements of the Proposed Action that are likely to affect the PBFs essential for the conservation of the MCR steelhead DPS (Table 3-4). Effects on designated critical habitat include the Proposed Action and associated mitigation that affect habitat within tributary spawning and rearing areas, the freshwater migration corridor, and estuarine areas.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of MCR steelhead. Freshwater spawning and rearing areas occur upstream of the CRS so the effects of the Proposed Action are limited to tributary habitat mitigation actions, which are intended to improve habitat function for MCR steelhead. For the tributary habitat improvement program there will be some uncertainty about the actual locations, extent, and types of tributary habitat actions that will be implemented as part of the Proposed Action. However, anticipated effects of the Tributary Habitat Improvement Program are expected to include short-term effects that will be mitigated through

compliance with the BiOp on Columbia River habitat improvements (NMFS), temporary impacts associated with stream restoration activities, and long-term positive effects associated with the tributary habitat improvement program.

Freshwater Migration Corridors

Freshwater migration corridors are used by returning adult steelhead migrating upstream through the CRS and by juvenile steelhead migrating downstream past Bonneville Dam. The four lower CRS dams and reservoirs have and will continue to affect critical habitat within the mainstem Columbia River, which continues to influence passage and survival of juvenile and adult migrants. The Proposed Action includes ongoing implementation of the Action Agency's predator management programs, which are intended to reduce the consumption of juvenile and adult salmon within the CRS. These programs will continue to reduce the risk of predation on MCR steelhead.

The Proposed Action also includes structural and operational modifications of the CRS that will affect water quality and passage conditions through which MCR steelhead must migrate to complete their life cycle. The overall effects of the Proposed Action are slightly positive with respect to passage conditions and risk of predation, and slightly negative with respect to a higher exposure to TDGs and incidence of GBT. Continued effects on stream temperature, sediment, and turbidity are anticipated within the CRS, but effects on those water quality indicators are likely to remain unchanged as a result of the Proposed Action. Passage conditions at each of the projects are anticipated to improve for juvenile steelhead because the flex spill program will provide more advantageous passage routes through spill bays at each of the projects. Increasing the proportion of water discharged through the spill bays at each of the dams will reduce forebay residence time by providing a more pronounced surface-oriented flow path for juvenile steelhead, which it is hypothesized will reduce latent mortality.

Estuarine and Nearshore Marine Areas

Estuary and nearshore ocean areas have been designated as essential for the conservation of MCR steelhead. Ongoing implementation of the CEERP and predator removal and harassment programs is anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of the CEERP is likely to increase the capacity and quality of habitat in the estuary while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal and harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to improve the safe passage feature of critical habitat.

The Proposed Action includes operational modifications to the CRS that may affect water quality habitat features downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions with a slight but potential increase in TDG associated with the flex spill program. The highest TDG levels (125 percent) are expected in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). Continued effects on the PBFs associated with stream temperature, sediment, and turbidity are anticipated downstream from the CRS

but are likely to remain unchanged as a result of the Proposed Action. Current passage habitat features will be unaffected for juvenile and adult MCR steelhead as they migrate through the Columbia River estuary and into the nearshore ocean.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on MCR steelhead in the context of environmental baseline and cumulative effects. Cumulative effects are effects of future state or private activities that are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline condition (whether they are federal, state, or private). To the extent those same activities are reasonably certain to occur in the future (and are state or private), their future effects are included in the cumulative effects analysis.

Most of the action, baseline, and cumulative effects identified in the analysis above are consistent with effects previously described for operation of the CRS in past consultations. In general, the Proposed Action as a whole is not likely to limit species survival or critical habitat function. It carries forward a suite of beneficial actions that improve baseline conditions and offset negative effects attributable to the regulation of flows, including flow augmentation, fish passage operations, predation management, and habitat improvement. Though the Proposed Action does not cause substantial changes to current species conditions, there may be some modest site-specific effects from the continued operation of the CRS. It is also possible that increased spill levels, and associated adverse effects, will be offset by an increase in adult returns due to less powerhouse encounters as hypothesized by the CSS.

The summary below follows the general structure of the effects analysis above, presenting operational and non-operational components.

Operational

Survival

Survival of juvenile MCR steelhead through the CRS is affected by the number of hydroprojects they pass, predators, travel time, and water quality. These factors are the result of the existence and continued operation of the CRS. Survival has improved for juvenile MCR steelhead migrating through the CRS to the ocean as a result of past actions. Juvenile steelhead survival has also improved in the estuary and tributaries because of habitat improvements implemented by the Action Agencies. For adult MCR steelhead, survival has been affected in the estuary up to Bonneville Dam by pinniped predators. Survival of adults that overshoot their natal tributaries and must pass downstream of dams to get back to their natal tributaries is an ongoing issue.

Future state and private actions, and the effects of climate change and variable ocean conditions have the potential to affect survival of MCR steelhead. Land use activities (primarily private) have the potential to affect juvenile survival by decreasing tributary and estuary habitat or degrading abiotic factors, such as temperature. Further degradation of tributary habitat could also affect adult MCR steelhead survival by reducing holding and spawning areas, or developing passage barriers. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies

implement fisheries that can have a direct effect on the number of steelhead returning to the MCR tributaries (and in some cases, within the tributaries themselves).

It is anticipated that survival gains that have resulted from previous actions will continue and possibly increase by continuing tributary and estuary habitat actions as well as continued improvement in juvenile and adult passage conditions at the CRS dams. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications of actions.

Travel Time

The building and operation of the CRS has slowed juvenile travel time compared to the pre-CRS condition, potentially increasing their exposure to predators as they migrate through the CRS. Travel times within the tributaries and estuary are not affected by the CRS. While the travel time of MCR juveniles within the CRS varies from year to year, actions from the past that are ongoing send more fish through non-turbine routes, which is believed to decrease travel time and improve survival. Adult travel time is not considered an issue. However, increased water temperatures may lead to migrational delays at fishways or result in natal tributary overshoot, both of which may reduce spawning success.

Future state and private actions are not expected to affect travel time of juveniles or adults through the CRS during any life stage. However, it is anticipated that projected increased air temperature due to climate change will continue to increase overall temperatures in the Columbia River, and therefore have the potential to further affect adult MCR upstream migrational timing, and possibly juvenile emigration timing.

The Proposed Action is anticipated to reduce forebay resident time for juvenile MCR migrating past CRS hydroprojects during implementation of the flexible spill plan. Continued monitoring of adult MCR steelhead migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse Passage Proportion

Past and current physical modifications and operations of the CRS hydroprojects have increased the percentage of juvenile fish passing via non-turbine routes. Decreasing powerhouse passage improves survival of juveniles during their downstream migration and earlier migrating adults that may fallback and have to migrate upstream past a dam again (by falling back through spill rather than the powerhouse).

The effects of state and private actions are not anticipated to affect juvenile MCR steelhead powerhouse passage.

The Proposed Action will continue the operations and actions that have resulted in increased non-turbine passage at the CRS projects. In addition, as techniques and additional operations are considered, further increases in non-turbine passage could occur.

Water Quality

Total Dissolved Gas

TDG levels have increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high rates that resulted in GBT in juveniles and adults as they migrated through the CRS. Elevated TDG levels are not observed within tributaries or the estuary (where the effects of CRS operations on TDG are attenuated by the distance from the dam and tributary flow, which dilute TDG levels). The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

The only state or private actions that will affect TDG levels in the mainstem Columbia River are modifications of state water quality criteria. For example, in 2020, it is anticipated that the Washington and Oregon water quality agencies will increase the allowable maximum level of TDG in the tailraces of CRS dams from 120 percent to 125 percent. Continued monitoring of juveniles and adults for signs of GBT will inform managers of the effects of this action.

Implementation of the flexible spill program is expected to elevate TDG levels to the state water quality limit, which may slightly increase the incidence of GBT in juvenile fish.

Temperature

Water temperatures have been modified as a result of a range of anthropogenic activities, including the existence and on-going operation of the CRS, throughout the Columbia River Basin. Increases in temperature can have a range of effects on both juvenile and adult MCR steelhead.

Ongoing non-federal land management activities that affect temperature, such as agriculture, urbanization, and forestry, are not expected to improve substantially. However, small improvements may be realized in the form tributary actions that restore and preserve habitat, like riparian plantings.

Implementation of the Proposed Action will continue to improve tributary temperatures, but will continue to have minimal effect on mainstem temperatures.

Turbidity

Currently, sediment loads in tributaries have been affected by historic land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and rearing habitat. In the mainstem Columbia River, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk.

In the tributaries, non-federal actions are likely to continue to affect turbidity, but improvements in tributary habitat included in the Proposed Action are expected to result in reduced sediment inputs, which will result in modest, site-specific improvements that will mitigate continued activities that degrade habitat. In the mainstem Columbia River, the current condition is not anticipated to change, and no non-federal activities are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat, and will most likely reduce sediment levels in the tributaries. On the mainstem Columbia River, the Proposed Action is not anticipated to change the current condition.

Dam Passage (adults)

Currently, MCR steelhead migrate upstream through one to four lower CRS projects on their way to natal spawning areas and experience a variety of factors affecting them, including harvest, dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish. MCR steelhead appear to survive their migration through the CRS at high levels, but some of them overshoot their natal tributaries, most likely to avoid high tributary temperatures. When these fish migrate back downstream to their natal tributaries, they may encounter dams on their migration that can affect their overall survival and spawning success. In addition, steelhead that survive spawning and try to return to the ocean (kelts) can be affected by the CRS.

Non-federal actions that have the potential to affect MCR adults migrating through the CRS include continued degradation of tributary habitat, which increase temperatures, and projected increased air temperature due to climate change that will likely warm surface water temperatures.

The Proposed Action will continue to monitor adult migration through the CRS, and use acquired information to propose specific actions that will increase adult survival.

Predation Rates

Currently, both juvenile and adult MCR steelhead encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinniped predators prey on adults as they enter the Columbia River from the ocean to the tailrace of Bonneville Dam. A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS, mostly in the tailraces of dams.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS has no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

Non-operational

Predation Management

The Proposed Action will continue to implement the predator management programs, which should ensure that predation does not worsen, and may reduce overall predation rates. Predation monitoring is implemented primarily to determine the effectiveness of the various predator management programs. Without this monitoring and evaluation, it would not be possible to understand whether the management programs are having the desired effect. Monitoring predator programs is not anticipated to be affected by any non-federal actions in the future. The Proposed Action will continue to fund and implement predator monitoring and evaluation programs that have been successful to date in determining the effectiveness of the current management programs.

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to operation of hydro facilities, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin salmon and steelhead and their habitat depends on the design of hatchery programs, the condition of the habitat, and the status of the species, among other factors.

Most hatchery programs are run by the state in which they occur. It is anticipated that most of the current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue.

The Proposed Action will continue to fund and monitor hatchery programs that mitigate for the CRS operations. The potential deleterious effects of hatchery-origin fish on natural-origin fish will continue to be studied, and management agencies will recommend how to reduce the potential effects.

Habitat Actions

Currently, habitat conditions in the tributaries, mainstem Columbia River, and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated by previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect MCR steelhead include continued degradation of tributary habitat that increases temperatures, and projected increased air temperature due to climate change that will likely warm surface water temperatures.

The Proposed Action will continue to rehabilitate habitat in the tributaries and estuary.

Fish Status and Trend Monitoring

There are potential effects from CRS-related RM&E programs on MCR steelhead. These are associated with the capturing and handling of fish. RM&E activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no non-federal actions anticipated that would affect RM&E activities.

The Proposed Action will continue to implement the RM&E programs that are currently occurring, and might modify these programs in the future as the results of the monitoring programs are evaluated.

Summary

The effects of the Proposed Action are summarized in Table 3-49, where the effects of the Proposed Action are compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action. Most of the actions are anticipated to either have no effect, or a positive effect compared to the current condition (Table 3-49). Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which

improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-49. Summary comparison of the Proposed Action to current conditions for MCR steelhead salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Fresh-water Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration
	Dam passage (adults; includes fallback and overshoot)		x	+	Potential positive effect from continued tributary habitat restoration (reducing temperature)
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Steel-head Down-stream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x		+	Continuation of predator management programs should decrease predation.
	Hatcheries	x		=	
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Juvenile Steelhead Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Steelhead Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Steelhead Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	-	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce overshoot.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Steelhead Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce overshoot.
Predation rates				Not applicable	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Hatcheries		x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring		x	=	

3.1.5 Lower Columbia River Salmonid Species

3.1.5.1 Lower Columbia River Coho Salmon

STATUS OF THE LOWER COLUMBIA RIVER COHO SALMON ESU

The LCR coho salmon ESU includes naturally spawned coho salmon originating from the Columbia River and its tributaries downstream from and including the White Salmon and Hood Rivers and any such fish originating from the Willamette River and its tributaries below Willamette Falls (Figure 3-22). The ESU spans three ecological regions (Coast, Cascade, and Gorge); each of these three ecological regions is considered a major population group containing a total of 24 independent populations. Coho salmon from 21 artificial propagation programs are included in the ESU (79 FR 20802 2014). On June 28, 2005, NMFS listed the LCR coho salmon ESU as a threatened species (70 FR 37160 2005). The threatened status was reaffirmed on April 14, 2014.

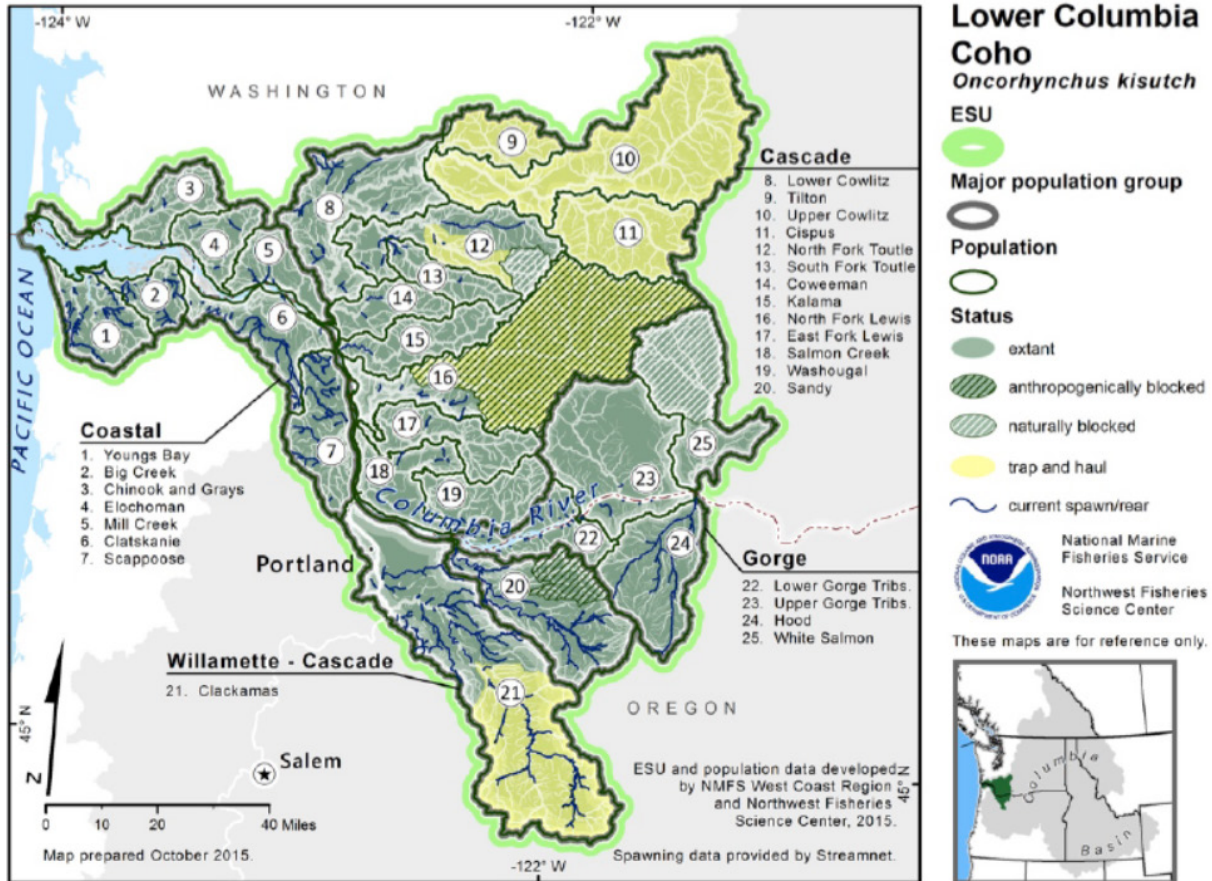


Figure 3-22. Map of the lower Columbia River coho salmon ESU's spawning and rearing areas, illustrating populations and major population groups (NMFS 2019)

McElhany et al. (2007) observed that, with the exception of the Clackamas and Sandy populations, it is likely that most of the wild LCR coho salmon populations were effectively extirpated in the 1990s and that no viable populations appear to exist in either the Coast or Gorge MPGs. A total of 6 of 24 populations are at or near their recovery viability goals, but under the recovery plan scenario none of these populations had recovery goals above 2.0 (moderate risk) (NMFS 2019).

The recent 5-year review leaves the Columbia River coho salmon status unchanged as threatened (NMFS 2016d). While the status was unchanged, the available data demonstrate short-term negative trends in abundance and a decrease in the number of spawners returning for the majority of populations in the ESU. However, the recent 5-year review concludes that although populations have generally improved, the ESU is still considered to be at moderate risk of extinction (NMFS 2016d). The review also noted that hatchery-origin fish dominated many of the populations. The recovery plan noted that

Very large improvements are needed in the persistence probability of most coho salmon populations if the ESU is to achieve recovery. (NMFS 2013)

FACTORS AFFECTING THE STATUS OF THE LCR COHO SALMON ESU

Within the range of LCR coho salmon, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation, such as degraded riparian conditions along tributaries, impaired side channel and wetland conditions in tributaries, loss/degradation of floodplain habitat in tributaries, channel structure and form issues in tributaries and the Columbia River estuary, sediment conditions in the estuary, direct mortality from fisheries, and reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish.

While recovery efforts have likely improved the status of a number of coho salmon populations, their abundances are still at low levels, and the majority of the populations remain at moderate or high risk. For the lower Columbia River region, land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. Although populations in this ESU have generally improved, especially in the 2013–14 and 2014–15 return years, recent poor ocean conditions suggest that population declines might occur in the upcoming return years (NMFS 2019).

Freshwater Spawning, Rearing, and Migration to the CRS

LCR coho salmon use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration.

Juvenile Downstream Migration Through the CRS

LCR coho salmon populations from two populations (Upper Gorge/White Salmon and Upper Gorge Tributaries/Hood) pass Bonneville Dam on their downstream migration. Juvenile LCR coho salmon pass downstream of the dam by many routes. Major modifications have been made to projects within the CRS to improve survival and achieve the 2008 BiOp hydroelectric power generation performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project.

In their 2019 BiOp, NMFS stated that

“Though there are no specific data for coho salmon, recent passage improvements have improved the survival of yearling Chinook salmon that pass through Bonneville Dam, are also likely to benefit coho salmon smolts. In our 2008 biological opinion, we estimate that 95.5 percent of yearling Chinook salmon that migrate past Bonneville Dam will survive; coho salmon smolts from tributaries and hatcheries in the Bonneville pool are likely to have similar levels of survival passing the dam.”

In addition, TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can get forced into solution when water passes over the spillway at a mainstem dam, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019).

Only 2 of the 24 LCR coho salmon populations (Upper Gorge/White Salmon and Upper Gorge Tributaries/Hood) are influenced directly by the operation of the CRS, including changes in sediment transport and spring flows. Therefore, changes in population abundance, positive or negative, are more likely a result of other anthropogenic or natural environmental conditions (NMFS 2019). It remains unlikely that future operations of the federal hydrosystem can dramatically affect the current distribution or abundance of LCR coho salmon.

Survival of LCR coho salmon is affected by avian and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple predation control measures to increase survival of juvenile salmonids in the lower Snake and lower Columbia Rivers through effective monitoring, hazing, and deterrents at each project. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019).

Juvenile Estuary Migration and Rearing, including the Plume

The estuary provides important habitat for LCR coho salmon populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also affected estuary ecosystems. For a more detailed discussion of estuary and plume conditions, see NMFS (2019). All of these conditions are part of the environmental baseline.

Avian predation continues to be a serious issue in the estuary. Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary may benefit this ESU by reducing the number of individuals of this ESU eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1]. The benefits from estuary habitat actions will continue over time.

This ESU may be exposed to estuary improvement actions, and may also benefit from increased capacity and quality of estuarine ecosystems. Increasing the accessibility, capacity, and quality of estuarine ecosystems provides the final opportunity for juvenile salmon to grow and improve their condition before entering the ocean.

Ocean Rearing

LCR coho salmon typically spend 2 years maturing in the ocean. During ocean residence, the mortality rate for anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2019). Of the factors that influence ocean productivity, which have been linked to salmonid growth and survival, the most influential is the PDO (Pacific Decadal Oscillation). However, other processes also contribute to ocean productivity such as the NCC (Northern California Current), the NPGO (North Pacific Gyre Oscillation), the ENSO (El Niño Southern Oscillation), climate change, and ocean acidification (NMFS 2019). All these factors will affect survival, directly or indirectly, because of their deleterious impacts on marine food webs.

In addition to climatic factors that can influence marine survival of LCR coho salmon, there is a potential for bycatch effects associated with ocean and sport fisheries. NMFS signed the 2018–27 *U.S. v. Oregon* Management Agreement for the Columbia River Basin. The decision was based on a recently completed Final EIS and the associated BiOp (*U.S. v. Oregon* 2018). 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 NMFS fulfills its trust/treaty responsibilities to Columbia Basin tribes. There is no direct commercial fishery for LCR coho salmon (NMFS 2019).

Adult Migration to and Through Bonneville Dam

For upstream migrating LCR coho salmon, the primary factor affecting survival to Bonneville Dam is pinniped predation. Estimates of pinniped predation downstream of the Bonneville Dam tailrace are not available by species, although salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019).

During upstream migration, these fish experience a variety of factors affecting the adult migration life-stage, including harvest (bycatch or catch and release), dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish [NMFS (2008b); Keefer et al. (2016); and Keefer and Caudill (2017) as cited in NMFS (2019)]. The primary factors influencing adult upstream passage through CRS dams are tailrace flow dynamics, sufficient attraction flows to fish ladder entrances, operation of ladders within established performance criteria, reduction of fallback, and maintenance of safe ladder temperatures and differentials (NMFS 2019).

Adult LCR coho salmon use fish ladders to swim past Bonneville Dam on their way to the spawning grounds. Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life stages such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

Adult Migration Upstream of the CRS to the Spawning Areas

After migrating upstream through the CRS past Bonneville Dam, adult LCR coho salmon begin to migrate to their natal streams. Once they enter those tributaries, they are no longer exposed to the operation and related effects of the CRS. Within these tributary habitats, a variety of non-operational actions, such as habitat improvement projects, have been implemented by the Action Agencies to benefit this ESU.

STATUS OF CRITICAL HABITAT

Critical habitat was designated for the LCR coho salmon ESU on February 24, 2016 (79 FR 59992). The areas designated as critical habitat for LCR coho salmon are all occupied and contain physical and biological features essential to the conservation of the species, which may require special management considerations or protection. No unoccupied areas were identified that are considered essential for the conservation of the species. There are 55 watersheds within the range of this ESU. Three watersheds received a low conservation value rating, 18 received a medium rating, and 34 received a high rating.

The lower Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value (NMFS 2019). The PBFs of critical habitat that are essential to the conservation of LCR coho salmon have been identified and include freshwater spawning, rearing and migration corridors, as well as estuarine and nearshore marine areas (Table 3-50) (NMFS 2019).

Removal of multiple barriers has improved access and allowed the restoration of hydrological processes that may improve downstream habitat conditions. However, the value of PBFs remains impaired by tributary barriers, loss of habitat complexity, toxics and water quality issues, concerns about predation during migration, and inundation of spawning sites by the Bonneville Pool (NMFS 2019).

Tributary barriers are a concern for freshwater spawning sites, freshwater rearing sites, and migration corridors. Water quality is a concern for all PBFs. Restoration activities addressing migration barriers and water quality have improved the baseline condition for PBFs, but more restoration is needed before the PBFs can fully support the conservation of LCR coho salmon (NMFS 2019).

The current literature indicates all habitats used by Pacific salmon will be affected by warmer temperatures and changed hydrology, but the impacts vary by habitat type. Some anticipated effects (e.g., increasing temperature) affect salmon at all life stages and in all habitats, while others are habitat specific, such as streamflow variation in freshwater, sea level rise in estuaries, and upwelling in the ocean.

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 (2009); Mote et al. (2014) as cited in NMFS (2019)]. 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) and ISAB (2007a) as cited in NMFS (2019)]. According to the ISAB, as cited in NMFS (2019), these effects pose the following impacts into the future:

- Projected 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, these watersheds will see their runoff diminished earlier in the season, resulting in lower streamflows in the June through September period. River flows in general and peak river flows are likely to increase during the winter because of more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when projected lower streamflows co-occur with projected warmer air temperatures.

Table 3-50. Physical and biological features and components and principal factors affecting the environmental baseline of critical habitat designated for LCR coho salmon [Reproduced from NMFS (2019); Table 2.7-4; Page 244].

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	Tributary barriers (culverts, dams, water withdrawals) Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) Excessive sediment in spawning gravel (forest and agricultural practices) Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) Inundation of spawning sites under Bonneville Reservoir (hydrosystem development)
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) Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) Excessive sediment in spawning gravel (forest and agricultural practices) Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quality, and natural cover	Delay and mortality of some juveniles and adults Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting, constricted passage opportunities for adult coho salmon in the Bonneville tailrace)

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
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
Nearshore marine areas (mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties)	Free of obstruction and excessive predation, with water quality and quantity and forage	Concerns about increased opportunities for pinniped predators and adequate forage

As reported by NMFS (2019), 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.).

PROPOSED ACTION COMPONENTS SPECIFIC TO LCR COHO SALMON

The Proposed Action, continuing to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2 of this document. Chapter 2 also provides details about the additional non-operational conservation measures for ESA-listed salmon and steelhead,

LCR coho salmon are exposed to the Proposed Action in the following ways:

- streamflow quantity and TDG changes from The Dalles Dam through the Bonneville Pool and to the ocean
- passage through Bonneville Dam during both downstream and upstream migrations.

Non-operational conservation measures of the Proposed Action include structural measures, conservation hatchery programs, predation management, and habitat improvement actions. Targeted RM&E to support adaptive management is part of many of these measures.

LCR coho salmon are exposed to conservation measures through

- avian and pinniped predator management actions in at Bonneville Dam and in the estuary
- HABITAT improvements in lower Columbia River tributaries and the estuary.

Based on their overall findings, NMFS (2019) concluded the following in their 2019 BiOp:

- 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, any effects of interrelated and interdependent activities, 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.

EFFECTS OF THE ACTION ON LCR COHO SALMON

The effects of the existence of the dam and reservoir system, and current operations, are part of the baseline and are not considered effects of the Proposed Action. The main effects on LCR coho salmon of continuing to operate and maintain the CRS are related to downstream and upstream passage through the CRS mainstem Bonneville Dam. This includes any delayed or latent mortality that may occur as a result of juvenile salmon passage at the dams. Improving juvenile and adult migration survival has been the focus of mitigation actions under past BiOps, and the benefits of these actions have been thoroughly documented [Corps et al. (2017a); Bonneville et al. (2018a), Appendix D]. These already-completed actions will continue to provide benefits in the future. The effects of the Proposed Action on this ESU and its critical habitat are described by life-stage below.

Both juvenile and adult LCR coho salmon from all populations will be exposed to the continuing effects of the Proposed Action in the mainstem Columbia River (Bonneville Pool) and estuary. The populations that migrate above Bonneville Dam (Upper Gorge/White Salmon and Upper Gorge Tributaries/Hood) will also be exposed to the habitat effects described above, as well as to changes in operations at Bonneville Dam.

Freshwater Spawning, Rearing, and Migration to the CRS

In the spawning and rearing areas, LCR coho salmon are not exposed to the effects of the CRS because no operations (e.g., flood risk management, irrigation, and power generation) occur in these areas. Because there is no exposure to these operations that are components of the Proposed Action, there are no direct effects on individual fish in these areas.

Some individual fish of this ESU may be exposed to improvements in the tributary habitat component of the Proposed Action. Improvement projects have primarily focused on the interior Columbia basin; however, if projects occurred in the lower Columbia River Basin, LCR coho salmon would benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that would result from the tributary actions. Adverse effects on individuals from actual implementation (i.e., construction) of habitat enhancement actions are mitigated through compliance with the Habitat Improvement Projects BiOp (NMFS 2013; USFWS 2013).

Juvenile Downstream Migration Through the CRS

For the populations that spawn upstream of Bonneville Dam, LCR coho salmon only encounter one CRS project, so none of the structural measures described in common effects for juvenile salmon and steelhead would apply to these fish. As there is no direct estimate of Bonneville Dam project survival specific to juvenile LCR coho salmon, the number is anticipated to be very low and no quantitative analysis was conducted specific to passage.

Juvenile LCR coho salmon from two populations (Upper Gorge/White Salmon and Upper Gorge Tributaries/Hood) are exposed to the effects of CRS operations once they reach the mainstem Columbia, and pass through Bonneville Dam to the estuary. In this migration corridor, juvenile LCR coho salmon will continue to experience the deleterious impacts of a degraded environmental baseline and associated cumulative effects.

In general, the Proposed Action will continue operations and implement actions to minimize impacts and increase survival of juvenile LCR coho salmon that pass through Bonneville Dam. Measures that have been implemented and will continue, include flow augmentation, spill, reduction of passage through turbines (e.g., through spill, surface passage and other juvenile bypasses), safer turbine passage, and predator management.

Changes in the Proposed Action compared to past operations include a flex spill operation and changed implementation of summer spill. Because juvenile LCR coho salmon do not migrate during the summer, any changes in summer spill will not affect this ESU. Changes in spring spill could result in an increased juvenile passage survival for LCR coho salmon that are passing through the CRS.

Juvenile Estuary Migration and Rearing, including the Plume

Estuarine and nearshore ecosystems provide habitat in which juvenile LCR coho salmon can forage and avoid predators. For example, most yearling salmonids tend to move through the estuary in 1 or 2 days, and survival in this reach appears to be high (Daly et al. 2014) excluding mortality associated with avian predation. The estuary is the final stretch of the Columbia River, where all outmigrating juvenile salmon and steelhead species affected by the CRS transition from freshwater to ocean conditions.

This ESU may be exposed to estuary improvement actions, and may also benefit from the increased capacity and quality of estuarine ecosystems. Increasing the accessibility, capacity, and quality of estuarine ecosystems provides the final opportunity for juvenile salmon to grow and improve their condition before entering the ocean.

Operation of the CRS has led to changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, the effects of CRS water management in the estuary are generally attenuated below Longview, WA by the distance from the facilities and inflow from tributaries like the Willamette and Cowlitz Rivers. Thus, any direct impacts from flow or elevated TDG in this area are expected to be minor. Proposed changes in water management are not expected to substantially change flows downstream of Bonneville Dam, and therefore, the factors that currently influence fish travel time to the estuary are not likely to change.

Avian predation continues to be a serious issue in the estuary. Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary will benefit this ESU by reducing the number of individuals of this ESU eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1].

Ocean Rearing

LCR coho salmon typically spend 2 years maturing in the ocean. During ocean residence, the mortality rate of anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2019). The Proposed Action will have no effect on the marine habitats used by LCR coho salmon for growth and maturing, because there are no CRS operations that affect this area.

Adult Migration to and through Bonneville Dam

CRS operations generally result in negligible changes in flow and TDG levels in the estuary. It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River by the distance from the facilities and the streamflows from lower river tributaries like the Willamette River. The Proposed Action causes no adult migration barriers for LCR coho salmon adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, and the Proposed Action will have no effect on pinniped predation. Thus, the Proposed Action is likely to have negligible effects on adult migration from the ocean to the CRS.

Adult LCR coho salmon from Columbia Gorge populations use fish ladders to swim past Bonneville Dam on their way to their spawning grounds. Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life stages such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

Adult Migration Upstream of the CRS to the Spawning Areas

After migrating upstream through the CRS, adult LCR coho salmon begin to migrate to their natal streams. Once they enter those tributaries, they are no longer exposed to the operation and related effects of the CRS. Within these tributary habitats, a variety of non-operational habitat improvement actions have been implemented by the Action Agencies to benefit this ESU.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Effects on critical habitat were assessed based on the elements of the Proposed Action that are likely to affect the PBFs essential for the conservation of the LCR coho salmon ESU (Table 3-51). Effects on designated critical habitat include the Proposed Action and associated mitigation that affect habitat within tributary spawning and rearing areas, the freshwater migration corridor, and estuarine areas.

Implementation of the Proposed Action is likely to affect passage at Bonneville Dam for 2 of the 24 populations. 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. The PBFs that could be affected by the Proposed Action are described in Table 3-51.

SUMMARY

The effects of the Proposed Action are summarized in Table 3-52, where the effects of the Proposed Action are compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action. Most of the actions are anticipated to either have no effect, or a positive effect compared to the current condition (Table 3-52). Positive

effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-51. Effects of the Proposed Action on the physical and biological features essential for the conservation of the LCR coho salmon ESU [Reproduced from NMFS (2019); Table 2.7-4; Page 244].

Physical and Biological Features (PBFs)	Effects of the Proposed Action
Freshwater spawning and rearing sites	The Proposed Action will continue the inundation of spawning habitat for coho salmon in the lower reaches of the tributaries to the Bonneville Pool. No changes are expected in rearing sites.
Freshwater migration corridors and estuarine areas	<p>Operations that have improved juvenile passage conditions for populations migrating through Bonneville Dam will continue.</p> <p>Increased levels of total dissolved gas (TDG; water quality) in Bonneville Reservoir and for at least 35 miles downstream of the dam. This area serves as critical habitat for the Gorge major population group (MPG) and one population in the Cascade MPG.</p> <p>Smolts are able to use behavioral mechanisms to avoid elevated TDG (i.e., by migrating deeper in the water column).</p> <p>The seasonal temperature regime will continue to be altered, exhibiting generally cooler temperatures in the spring and warmer temperatures in the fall, relative to historical conditions.</p> <p>Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could make juveniles more vulnerable to predation.</p> <p>Because estuary bird colonies and predation rates are in flux, it is not clear whether continued tern and cormorant colony management is likely to reduce avian predation (i.e., meet management plan goals). Any reduced predation rates achieved under the 2008 BiOp and associated Reasonable and Prudent Alternative will continue under this Proposed Action.</p> <p>Continuation of the pikeminnow removal program and pinniped program will improve survival through the mainstem migration corridor.</p>

Table 3-52. Summary comparison of the Proposed Action to current conditions for LCR coho salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration
	Dam passage (adults; includes fallback and overshoot)		x	+	Potential positive effect from continued tributary habitat restoration (reducing temperature)
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Coho Down-stream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x		+	Continuation of predator management programs should decrease predation.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Hatcheries	x		=	
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Juvenile Coho Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
Ocean Rearing	Fish status and trend monitoring	x		=	
	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Coho Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
Adult Coho Migration Through CRS Dams	Fish status and trend monitoring		x	=	
	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce fallback.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Coho Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable
Fish status and trend monitoring		x	=		

3.1.5.2 Lower Columbia River Chinook Salmon

STATUS OF THE LOWER COLUMBIA RIVER CHINOOK SALMON ESU

The LCR Chinook salmon ESU includes all naturally spawned populations from the mouth of the Columbia River and tributaries upstream to and including White Salmon River in Washington and Hood River in Oregon. This ESU also includes the Willamette River upstream to Willamette Falls (exclusive of spring-run Chinook salmon in the Clackamas River), and 15 artificial propagation programs included in the ESU (79 FR 20802) (Figure 3-23). The ESU spans three distinct ecological regions (Coast, Cascade, and Gorge) and includes three distinct life-history types (spring-run, fall-run, and late-fall-run). There are 32 demographically-independent populations in this ESU that are organized into six MPGs: spring-run Cascade, spring-run Gorge, fall-run Coastal, fall-run Cascade, Fall-run Gorge, and late fall-run Cascade (NWFSC (Northwest Fisheries Science Center) 2015). On March 24, 1999, NMFS listed the LCR Chinook salmon ESU as a threatened unit (64 FR 14307). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160). Critical habitat was designated on July 2, 2005 (70 FR 52630).

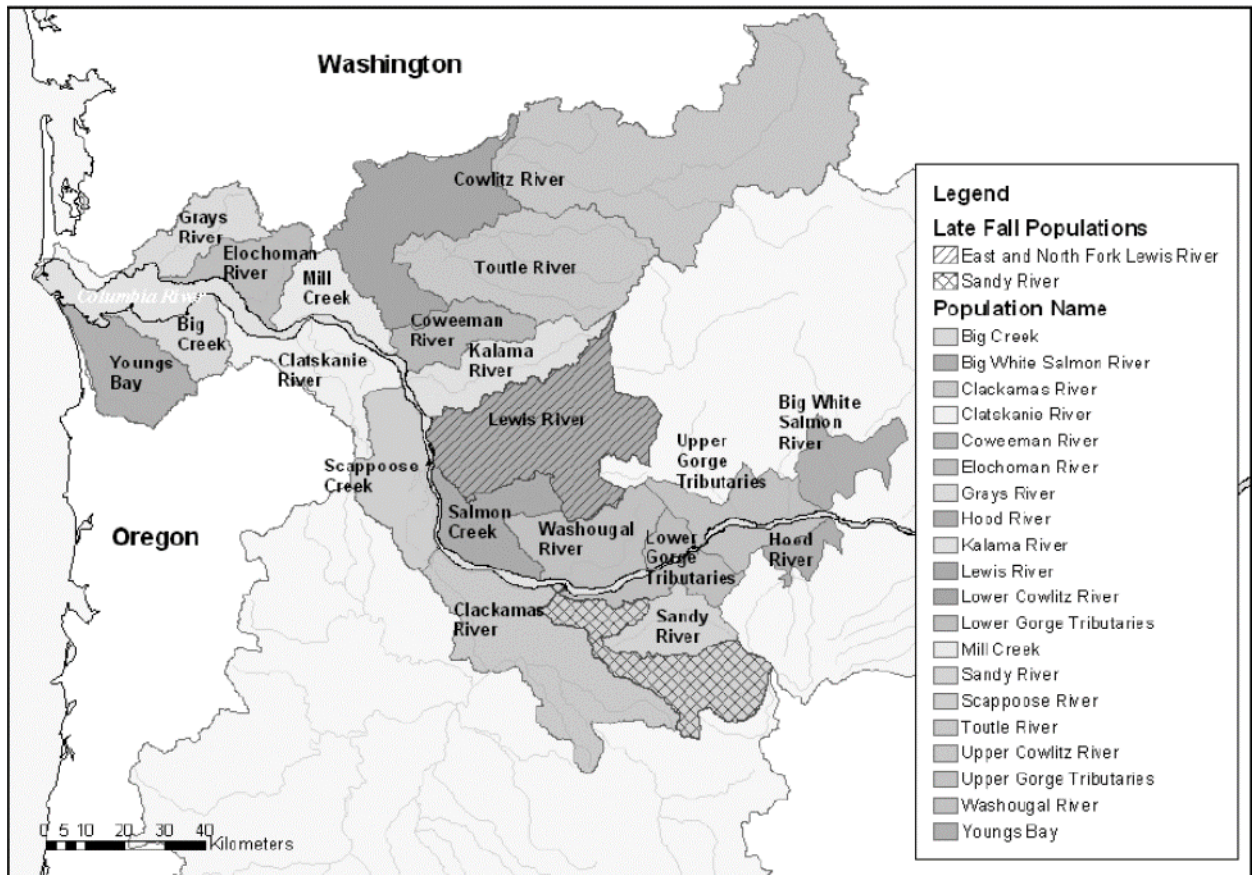


Figure 3-23. LCR Chinook salmon ESU range and population structure (Good et al. 2005)

The recent 5-year Status Review leaves the CR Chinook salmon status unchanged as threatened (NMFS 2016d). Although the status was unchanged, about 70 percent of the fall-run populations increased, and the hatchery contributions decreased for several populations (NMFS 2016d). The 2016 Status Review also noted that relatively high harvest rates were a potential concern (NMFS 2016d). Relative to baseline

viable salmonid population (VSP) levels identified in the recovery plan, there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals (NMFS 2019). Of the 12 historical naturally reproducing Chinook populations in Oregon's portion of the lower Columbia River, only four can be confirmed as being present: the early fall Chinook population in the Clatskanie River, the late fall population in the Sandy River, and the spring Chinook populations in the Sandy and Clackamas Rivers (NMFS 2016d). While the LCR Chinook salmon recovery plan identifies the goals of restoring the Cascade and Gorge MPGs to a high probability of persistence or to a probability of persistence consistent with their historical condition (NMFS 2013), very large improvements will be needed in most populations to achieve recovery (NMFS 2019). The recovery plan noted that only two populations of LCR Chinook (the Lewis and Sandy Rivers populations) have a baseline probability of persistence that is high or very high (NMFS 2013).

Only 5 of 32 populations in this ESU are affected by passage conditions at Bonneville Dam and, to a lesser extent, The Dalles Dam: Upper Gorge fall-run, White Salmon fall-run, Hood River fall-run, White Salmon spring-run, and Hood River spring-run Chinook salmon. Adult LCR Chinook salmon PIT detections at Bonneville Dam (2008–2017) recorded a total of 38 adults detected at Bonneville Dam across the 5 years, with a range of zero fish in 2008 to 21 fish in 2016 (NMFS 2019).

FACTORS AFFECTING THE STATUS OF LCR CHINOOK SALMON ESU

In general, wild Chinook in the lower Columbia River Basin are thought to be substantially reduced compared to historical levels. As noted above, only 38 LCR Chinook salmon were detected at Bonneville Dam between 2008-17 (NMFS 2019). Changes in population abundance at the ESU level, positive or negative, are more likely a result of other anthropogenic or natural environmental conditions. It remains unlikely that future operations of the federal hydrosystem can dramatically affect current distribution or abundance of LCR Chinook.

Limiting factors for LCR Chinook salmon include reduced access to spawning and rearing habitat, hatchery and harvest-related effects, altered flow regimes, reduced productivity in the estuary, and contaminants and concerns about adverse effects to diversity and productivity (NMFS 2019).

Freshwater Spawning, Rearing, and Migration to the CRS

LCR Chinook salmon use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. Degraded habitat conditions are an additional concern, particularly with regard to tributary channel complexity, side channel and floodplain connectivity, water quality, and hydrologic patterns that are legacy effects of urbanization, agriculture, timber practices, and toxic contamination from exposure to emerging and legacy chemicals (NMFS 2019).

Juvenile Downstream Migration Through the CRS

Any extant LCR Chinook salmon from the White Salmon and Hood Rivers populations pass Bonneville Dam on their downstream migration. Juvenile LCR Chinook salmon could pass downstream of the dam by many routes. Major modifications have been made to projects within the CRS to improve survival and achieve the 2008 BiOp hydroelectric power generation performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project.

Survival of LCR Chinook salmon is affected by avian, pinniped, and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple 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. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019).

The survival of downstream migrants has improved in recent years due to the construction of the Bonneville Corner Collector and JBS at Powerhouse 2, and increases in the percent of flow approaching the dam that goes over the spillway (NMFS 2019).

Juvenile Estuary Migration and Rearing, Including the Plume

Estuarine and nearshore ecosystems provide habitat for juvenile LCR Chinook salmon to forage and avoid predators. For example, most yearling salmonids tend to move through the estuary in a few days (Daly et al. 2014). Subyearlings may linger in the estuary for a longer period. The estuary is the final stretch of the Columbia River, where all outmigrating juvenile salmon and steelhead species affected by the CRS transition from freshwater to ocean conditions.

NMFS (2019) noted that the variety of nonindigenous fishes in the lower Columbia River recovery domain affect salmon and their ecosystems. 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) and Gustafson et al. (2010) as cited in NMFS (2019)].

This ESU may be exposed to estuary improvement actions, and may also benefit from increased capacity and quality of estuarine ecosystems. Increasing the accessibility, capacity, and quality of estuarine ecosystems provides the final opportunity for juvenile salmon to grow and improve their condition before entering the ocean.

In addition, there is an apparent relationship between plume characteristics at time of ocean entry and SARs for some salmonids. For example, Jacobson et al. (2012) found that steelhead SARs increased with the size and offshore distance of the plume under favorable large-scale ocean conditions, but did not change when ocean conditions were poor (Jacobson et al. 2012).

Avian predation continues to be a serious issue in the estuary. Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary will benefit this ESU by reducing the number of individuals of this ESU eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a)]. Benefits resulting from the estuary habitat actions will continue over time.

Ocean Rearing

LCR Chinook salmon typically spend 1 to 3 years maturing in the ocean. During ocean residence, the mortality rate of anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2019). Of the factors that influence ocean productivity, which have been linked to salmonid growth and survival, the most influential is the PDO. However, other processes also contribute to ocean productivity such as the NCC, the NPGO, the ENSO,

climate change, and ocean acidification (NMFS 2019). All these factors will affect survival, directly or indirectly, because of their deleterious impacts on marine food webs.

In addition to these climatic factors influencing marine survival of LCR Chinook salmon, commercial and sport fisheries continue to have an exploitation rate of 30 to 40 percent. NMFS signed the 2018–27 *U.S. v. Oregon* Management Agreement of the Columbia River Basin. The decision was based on a recently completed Final EIS and the associated BiOp (*U.S. v. Oregon* 2018). 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 NMFS fulfills its trust/treaty responsibilities to Columbia Basin tribes.

Adult Migration to and through Bonneville Dam

Few individual LCR Chinook salmon are affected by passage conditions at Bonneville Dam (NMFS 2019). Extant adult LCR Chinook salmon from the Columbia Gorge populations would use fish ladders to swim past Bonneville Dam on their way to the spawning grounds. Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life stages such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

CRS operations generally result in negligible changes in flow and TDG levels in the estuary. It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River by the distance from the facilities and the streamflows from lower river tributaries like the Willamette River. The Proposed Action causes no adult migration barriers for LCR Chinook salmon adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. Thus, the Proposed Action is likely to have negligible effects on adult migration from the ocean to the CRS.

Improved ocean fisheries management and implementation of selective freshwater fisheries continue to reduce harvest impacts, with the exception of the up-river bright fall-run component of the LCR Chinook salmon ESU, for which harvest rates were up to 40 to 65 percent in recent years, equivalent to the harvest rates of the early 1980s (NMFS 2019).

Adult Migration Upstream of the CRS to the Spawning Areas

After migrating upstream through the estuary, and possibly past Bonneville Dam, adult LCR Chinook salmon begin to migrate to their natal streams. Once they enter those tributaries, they are no longer exposed to the operation and related effects of the CRS. Within these tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this ESU.

Notably, dam removals (i.e., Condit Dam, Marmot Dam, and Powerdale Dam) not only improve/provide access, but also allow the restoration of hydrological processes that may improve downstream habitat conditions for Columbia Gorge populations.

STATUS OF CRITICAL HABITAT

Critical habitat was designated for the LCR Chinook salmon ESU on September 2, 2005 (70 FR 52630). The areas designated as critical habitat for LCR Chinook salmon are all occupied and contain physical and biological features essential to the conservation of the species, which may require special management considerations or protection. Designated critical habitat encompasses 10 subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most hydrologic unit code 5 (HUC5) watersheds with PBFs for LCR Chinook salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement (NMFS 2019).

The PBFs for LCR Chinook salmon critical habitat include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas (Table 3-53). Removal of multiple barriers has improved access and allowed the restoration of hydrological processes that may improve downstream habitat conditions. However, the value of PBFs remains impaired by tributary barriers, loss of habitat complexity, toxics and water-quality issues, concerns about predation during migration, and inundation of spawning sites for extant Columbia Gorge populations by the Bonneville Pool.

Table 3-53. Physical and biological features and components and principal factors affecting the environmental baseline of critical habitat designated for LCR Chinook salmon [Reproduced from NMFS (2019); Table 2.5-5; Page 166]

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	Tributary barriers (culverts, dams, water withdrawals) Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) Excessive sediment in spawning gravel (forest and agricultural practices) Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) Inundation of spawning sites under Bonneville Reservoir (hydrosystem development)

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors Affecting Environmental Baseline Condition of the PBFs
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) Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) Excessive sediment in spawning gravel (forest and agricultural practices) Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	Delay and mortality of some juveniles and adults Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting, constricted passage opportunities for adult Chinook salmon in the Bonneville tailrace)
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
Nearshore marine areas (mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties)	Free of obstruction and excessive predation, with water quality and quantity and forage	Concerns about increased opportunities for pinniped predators and adequate forage

PROPOSED ACTION COMPONENTS SPECIFIC TO LCR CHINOOK SALMON

The Proposed Action, continuing to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2 of this document. Chapter 2 also provides details about the additional non-operational conservation measures for ESA-listed salmon and steelhead,

LCR Chinook salmon are exposed to the Proposed Action in the following ways:

- streamflow quantity and TDG changes from the Dalles Dam through the Bonneville Pool and to the ocean
- passage through Bonneville Dam in both the downstream and upstream migrations.

Non-operational conservation measures of the Proposed Action include structural measures, conservation hatchery programs, predation management, and habitat improvement actions. Targeted RM&E to support adaptive management is part of many of these measures.

LCR Chinook salmon are exposed to conservation measures through

- avian and pinniped predator management actions in at Bonneville Dam and in the estuary
- habitat improvements in lower Columbia River tributaries and the estuary.

Based on their overall findings, (NMFS 2019) concluded the following in their 2019 BiOp:

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, any effects of interrelated and interdependent activities, 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.

EFFECTS OF THE ACTION ON LCR CHINOOK SALMON

The effects of the existence of the dam and reservoir system, and current operations, are part of the baseline and are not considered effects of the Proposed Action. The main effects on LCR Chinook salmon of continuing to operate and maintain the CRS are related to downstream and upstream passage through the CRS mainstem Bonneville Dam. This includes any delayed or latent mortality that may occur as a result of juvenile salmon passage at the dams. Improving juvenile and adult migration survival rate has been the focus of mitigation actions under past BiOps, and the benefits of these actions have been thoroughly documented [Corps et al. (2017a); Bonneville et al. (2018a), Appendix D]. These already-completed actions will continue to provide benefits in the future. The effects of the Proposed Action on this ESU and its critical habitat are described by life stage below.

Both juvenile and adult LCR Chinook salmon from all populations will be exposed to the continuing effects of the Proposed Action in the mainstem Columbia River (Bonneville Pool). The populations that may migrate above Bonneville Dam (Upper Gorge fall-run, White Salmon fall-run, Hood River fall-run, White Salmon spring-run, and Hood River spring-run Chinook salmon) will also be exposed to the habitat effects described above, as well as to changes in operations at Bonneville Dam.

Freshwater Spawning, Rearing, and Migration to the CRS

In the spawning and rearing areas, LCR Chinook salmon are not exposed to the effects of the CRS because no operations (e.g., flood risk management, irrigation, power generation) occur in these areas. Because there is no exposure to these operations that are components of the Proposed Action, there are no direct effects on individual fish in these areas.

Some individual fish of this ESU may be exposed to improvements in the tributary habitat component of the Proposed Action. Improvement projects have primarily focused on the interior Columbia River Basin; however, if projects occurred in the lower Columbia River, LCR Chinook salmon would benefit from improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that would result from the tributary actions. Adverse effects on individuals from actual implementation (i.e., construction) of habitat enhancement actions are mitigated through compliance with the Habitat Improvement Projects BiOp (NMFS 2013; USFWS 2013).

Juvenile Downstream Migration Through the CRS

Juvenile LCR Chinook salmon from extant Columbia Gorge populations (Upper Gorge fall-run, White Salmon fall-run, Hood River fall-run, White Salmon spring-run, and Hood River spring-run Chinook salmon) are exposed to the effects of CRS operations once they reach the mainstem Columbia River, and pass through Bonneville Dam to the estuary. In this migration corridor, juvenile LCR Chinook salmon will continue to experience the deleterious impacts of a degraded environmental baseline and associated cumulative effects.

In general, the Proposed Action will continue operations and implement actions to minimize impacts and increase the survival of juvenile LCR Chinook salmon that pass through Bonneville Dam. Measures that have been implemented and will continue, include flow augmentation, spill, reduction of passage through turbines (e.g., through spill, surface passage and other juvenile bypasses), safer turbine passage, and predator management.

Changes in the Proposed Action compared to past operations include a flex spill operation and changed implementation of summer spill. Because juvenile LCR Chinook salmon do not migrate during the summer, any changes in summer spill will not affect this ESU. Changes in spring spill could result in an increased juvenile passage survival rate for LCR Chinook salmon that are passing through the CRS.

Juvenile Estuary Migration and Rearing, Including the Plume

This ESU may be exposed to estuary improvement actions, and may also benefit from increased capacity and quality of estuarine ecosystems. Increasing the accessibility, capacity, and quality of estuarine ecosystems provides the final opportunity for juvenile salmon to grow and improve their condition before entering the ocean.

Operation of the CRS has led to changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, the effects of CRS water management in the estuary are generally attenuated below Longview, WA by the distance from the facilities and inflow from tributaries like the Willamette and Cowlitz Rivers. Thus, any direct impacts from flow or elevated TDG in this area are expected to be minor. Proposed changes in water management are not expected to substantially change flows downstream of Bonneville Dam, and therefore, the factors that currently influence fish travel time to the estuary are not likely to change.

Avian predation continues to be a serious issue in the estuary. Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary will benefit this ESU by

reducing the number of individuals of this ESU eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1]. Benefits resulting from the estuary habitat actions will continue over time.

Ocean Rearing

LCR Chinook salmon typically spend 2 to 3 years maturing in the ocean. During ocean residence, mortality of anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2019). The Proposed Action will have no effect on the marine habitats used by LCR Chinook salmon for growth and maturing because there are no CRS operations that affect this area.

Adult Migration To and Through Bonneville Dam

CRS operations generally result in negligible changes in flow and TDG levels in the estuary. It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River by the distance from the facilities and the streamflows from lower river tributaries like the Willamette River. The Proposed Action causes no adult migration barriers for LCR Chinook salmon adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. Thus, the Proposed Action is likely to have negligible effects on adult migration from the ocean to the CRS.

A few adult LCR Chinook salmon from extant Columbia Gorge populations use fish ladders to swim past Bonneville Dam on their way to the spawning grounds. Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life stages such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

Adult Migration Upstream of the CRS to the Spawning Areas

After migrating upstream through the CRS, adult LCR Chinook salmon begin to migrate to their natal streams. Once they enter those tributaries, they are no longer exposed to the operation and related effects of the CRS. Within these tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this ESU.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Effects to critical habitat were assessed based on those elements of the Proposed Action that are likely to affect the physical and biological features (PBF) essential for the conservation of the LCR Chinook salmon ESU (Table 3-54). Effects to designated critical habitat include the Proposed Action and

associated mitigation that affect habitat within tributary spawning and rearing areas, the freshwater migration corridor, and estuarine areas.

Implementation of the Proposed Action is likely to affect passage at Bonneville Dam for two of the 24 populations. 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. The PBFs that could be affected by the Proposed Action are described in Table 3-54.

Table 3-54. Effects of the Proposed Action on the physical and biological features (PBFs) essential for the conservation of the LCR coho salmon ESU [Reproduced from NMFS (2019); Table 2.7-4; Page 244]

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning and rearing sites	The Proposed Action will continue the inundation of spawning habitat for fall-run LCR Chinook salmon in the lower reaches of the tributaries to the Bonneville Pool. No changes are expected to rearing sites.
Freshwater migration corridors and estuarine areas	<p>Operations that have improved juvenile passage conditions for populations migrating through Bonneville Dam will continue.</p> <p>Increased levels of total dissolved gas (TDG; water quality) in Bonneville Reservoir and for at least 35 miles downstream of the dam. This area serves as critical habitat for the Columbia Gorge MPG.</p> <p>Smolts are able to use behavioral mechanisms to avoid elevated TDG (i.e., by migrating deeper in the water column).</p> <p>The seasonal temperature regime will continue to be altered, exhibiting generally cooler temperatures in the spring and warmer temperatures in the fall, relative to historic conditions.</p> <p>Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could make juveniles more vulnerable to predation.</p> <p>Because estuary bird colonies and predation rates are in flux, it is not clear whether continued tern and cormorant colony management is likely to reduce avian predation (i.e., meet management plan goals). Any reduced predation rates achieved under the previous CRS consultations and associated mitigation will continue under this Proposed Action.</p> <p>Continuation of the pikeminnow removal program and pinniped program will improve survival through the mainstem migration corridor.</p>

SUMMARY

The effects of the Proposed Action are summarized in Table 3-55, where the effects of the Proposed Action are compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action. Most of the actions are anticipated to either have no effect, or a positive effect compared to the current condition (Table 3-55). Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile

travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-55. Summary comparison of the Proposed Action to current conditions for LCR Chinook salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration
	Dam passage (adults; includes fallback and overshoot)		x	+	Potential positive effect from continued tributary habitat restoration (reducing temperature)
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Chinook Down-stream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x		+	Continuation of predator management programs should decrease predation.
	Hatcheries	x		=	
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Juvenile Chinook Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Chinook Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Chinook Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce fallback.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Chinook Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable

CRS Biological Assessment

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Hatcheries		x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring		x	=	

3.1.5.3 Lower Columbia River Steelhead

STATUS OF THE LOWER COLUMBIA RIVER STEELHEAD DPS

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. The LCR steelhead DPS includes 23 extant anadromous populations in four major population groups (Figure 3-24). This DPS includes both summer- and winter-run types. Generally, summer 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 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 to be 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); and Hulett et al. (1996) as cited in NMFS (2019)]. Many of the populations in this DPS are small, and many of the abundance trends for these populations are negative. A number of the populations have a substantial fraction of hatchery-origin spawners. This DPS includes steelhead from seven artificial propagation programs (79 FR 20802). The DPS was listed as threatened under the ESA in 1998, and was reaffirmed as threatened in 2014 (79 FR 20802).

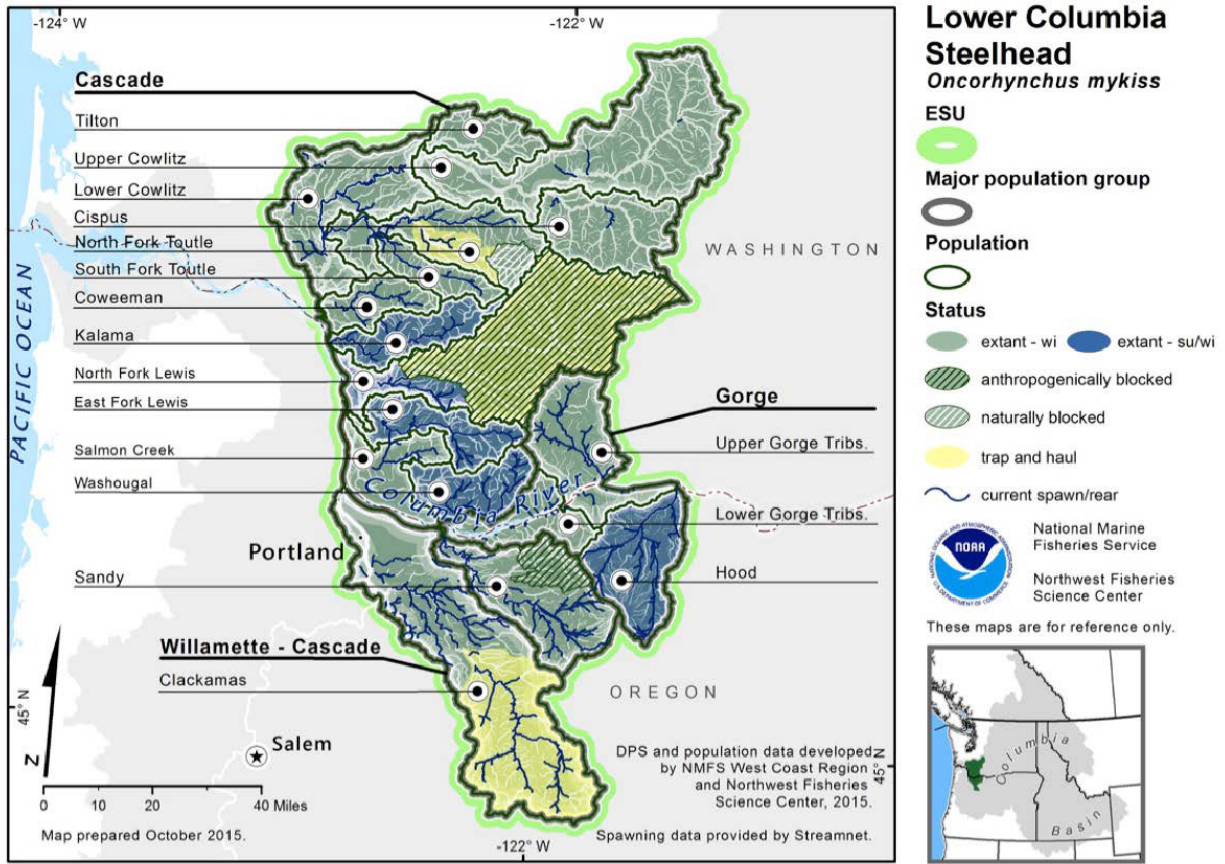


Figure 3-24. Map of populations in the LCR steelhead DPS [Sources: NWFS (Northwest Fisheries Science Center) (2015)]

The recent 5-year Status Review leaves the CR steelhead status unchanged as threatened (NMFS 2016d). While the status was unchanged, the limited data available demonstrate overall positive trends in abundance and an increase in the number of spawners returning for the DPS.

The Status Review noted that the majority of natural-origin LCR steelhead persist at low abundances, and that hatchery interactions and habitat degradation remain of concern (NMFS 2016d). Although there have been modest status improvements, the ESU is still considered to be at moderate risk of extinction (NMFS 2016d). The recovery plan noted that most populations have maintained their spatial structure (NMFS 2013).

All populations are affected by habitat alteration (loss of floodplain connection, shallow-water rearing habitats) in the Columbia River mainstem and estuary. Five out of 22 populations are at or near their recovery viability goals. However, only four of these populations are influenced directly by CRS operations. Therefore, changes in population abundance, positive or negative, are more likely a result of other anthropogenic or natural environmental conditions. It remains unlikely that future operations of the federal hydrosystem can dramatically affect the current distribution or abundance of LCR steelhead.

FACTORS AFFECTING THE STATUS OF LCR STEELHEAD DPS

The primary limiting factors for LCR winter steelhead populations include degraded riparian conditions along tributaries; channel structure and form issues in tributaries and the estuary; impaired side channel and wetland conditions in tributaries; loss/degradation of floodplain habitat in tributaries; sediment conditions in the estuary; altered hydrology in the estuary; and avian and marine mammal predation (NMFS 2013). The primary limiting factors for summer steelhead populations include all of the above with the addition of sediment conditions in tributaries, and do not include channel structure and form issues in the estuary. Tributary hydropower development is a primary limiting factor for the North Fork Lewis summer population and several populations in the Cascade winter steelhead MPG. Stray hatchery fish interbreeding with natural-origin fish is also a concern (NMFS 2019).

Only four of the 23 populations in this DPS are affected by passage conditions at Bonneville Dam: Wind summer steelhead, Hood summer steelhead, Hood winter steelhead, and Upper Gorge winter steelhead. Based on PIT detections, small numbers of adult LCR steelhead (about 10 per year) also migrate upstream of The Dalles Dam (NMFS 2019).

There is no direct harvest of naturally produced LCR steelhead other than a catch and release fishery in the Wind River (NWFSC (Northwest Fisheries Science Center) 2015). They are intercepted in mainstem fisheries targeting unlisted hatchery and naturally produced Chinook salmon and unlisted steelhead.

Freshwater Spawning, Rearing, and Migration to the CRS

LCR steelhead use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. 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 (NMFS 2019).

Juvenile Downstream Migration Through the CRS

LCR steelhead populations from the Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run populations pass Bonneville, The Dalles, and John Day Dams on their downstream migration. Juvenile LCR steelhead pass downstream of the dam by many routes. Major modifications have been made to projects within the CRS to improve survival and achieve the 2008 BiOp hydroelectric power generation performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project.

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. Upstream passage to potential spawning grounds is limited by Bonneville Dam, and inundation of historical habitat has reduced habitat quantity for juveniles (NMFS 2019).

In addition, TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can get forced into solution when water passes over the spillway at a mainstem dam, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem

dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019).

Only four of the 23 LCR steelhead populations (Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run) are influenced directly by the operation of the CRS, including changes in sediment transport and spring flows. Therefore, changes in population abundance, positive or negative, are more likely a result of other anthropogenic or natural environmental conditions. It remains unlikely that future operations of the federal hydrosystem can dramatically affect current distribution or abundance of LCR steelhead.

Survival of LCR steelhead is affected by avian and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple 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. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019).

Juvenile Estuary Migration and Rearing, Including the Plume

The estuary provides important habitat for LCR steelhead populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also affected estuary ecosystems. For a more detailed discussion of estuary and plume conditions, see NMFS (2019). All of these conditions are part of the environmental baseline.

Avian predation continues to be a serious issue in the estuary. Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary will benefit this ESU by reducing the number of individuals of this ESU eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1].

This ESU may be exposed to estuary improvement actions, and may also benefit from the increased capacity and quality of estuarine ecosystems. Increasing the accessibility, capacity, and quality of estuarine ecosystems provides the final opportunity for juvenile salmon to grow and improve their condition before entering the ocean.

Ocean Rearing

LCR steelhead typically spend 1 to 2 years maturing in the ocean. During ocean residence, the mortality of anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2019). Of the factors that influence ocean productivity, which have been linked to salmonid growth and survival, the most influential is the PDO. However, other processes also contribute to ocean productivity such as the NCC, the NPGO, the ENSO, climate change, and ocean

acidification (NMFS 2019). All these factors will affect survival, directly or indirectly, because of their deleterious impacts on marine food webs.

In addition to climatic factors that can influence marine survival of LCR steelhead, there is a potential for bycatch effects associated with ocean and sport fisheries. As noted above, there is no direct harvest of naturally produced LCR steelhead, but they are intercepted in mainstem fisheries targeting unlisted hatchery and naturally produced Chinook salmon and unlisted steelhead (NMFS 2019).

Adult Migration to and through Bonneville Dam

For upstream migrating LCR steelhead from the Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run populations, the primary factor affecting survival to Bonneville Dam is pinniped predation. Estimates of pinniped predation downstream of the Bonneville Dam tailrace are not available by species, although salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019).

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) (NMFS 2019).

During upstream migration, these fish experience a variety of factors affecting the adult migration life-stage, including harvest (bycatch or catch and release), dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish [NMFS (2008b); Keefer et al. (2016); and Keefer and Caudill (2017) as cited in NMFS (2019)]. The primary factors influencing adult upstream passage through CRS dams are tailrace flow dynamics, sufficient attraction flows to fish ladder entrances, operating ladders within established performance criteria, reduction of fallback, and maintenance of safe ladder temperature and differentials (NMFS 2019).

Adult LCR steelhead from the Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run populations use fish ladders to swim past Bonneville Dam on their way to the spawning grounds. NMFS reviewed LCR steelhead PIT detections at Bonneville, The Dalles, and McNary Dams from 2008 through 2017 (data are only available starting in 2013 for The Dalles Dam). The 5-year average of LCR steelhead detections is 296 adults at Bonneville Dam, 10 adults at The Dalles Dam, and <1 at McNary Dam. No PIT-detection data are available for John Day Dam, but we assume that a small number of LCR steelhead ascend John Day Dam and use the John Day Pool. Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species since they have survived high-mortality life-stages such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

Adult Migration Upstream of the CRS to the Spawning Areas

After migrating upstream through the CRS past Bonneville Dam, adult LCR steelhead from the Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run populations begin to migrate to their natal streams. Once they enter those tributaries, they are no longer exposed to the operation and related effects of the CRS. Within these tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this ESU.

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 2013).

STATUS OF CRITICAL HABITAT

Critical habitat was designated for LCR steelhead on September 2, 2005 (70 FR 52630). It encompasses nine subbasins in Oregon and Washington containing 41 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. The PBFs of critical habitat that are essential to the conservation of LCR steelhead have been identified and include freshwater spawning, rearing and migration corridors, as well as estuarine and nearshore marine areas (Table 3-56) (NMFS 2019). Tributary barriers are a concern for freshwater spawning sites, freshwater rearing sites, and migration corridors. Removal of multiple barriers has improved access and allowed the restoration of hydrological processes that may improve downstream habitat conditions. Water quality is a concern for all PBFs. Restoration activities addressing migration barriers and water quality have improved the baseline condition for PBFs; however, more restoration is needed before the PBFs can fully support the conservation of LCR steelhead (NMFS 2019).

Table 3-56. Physical and biological features and components and principal factors affecting the environmental baseline of critical habitat designated for LCR steelhead (reproduced from NMFS (2019); Table 2.6-5; Page 207).

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors affecting Environmental Baseline Condition of the PBFs
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	Tributary barriers (culverts, dams, water withdrawals) Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) Excessive sediment in spawning gravel (forest and agricultural practices) Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) Inundation of spawning sites under Bonneville Reservoir (hydrosystem development)

Physical and Biological Features (PBFs)	Components of the PBFs	Principal Factors affecting Environmental Baseline Condition of the PBFs
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) Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) Excessive sediment in spawning gravel (forest and agricultural practices) Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	Delay and mortality of some juveniles and adults Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting, constricted passage opportunities for adult steelhead in the Bonneville tailrace)
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
Nearshore marine areas (mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties)	Free of obstruction and excessive predation, with water quality and quantity and forage	Concerns about increased opportunities for pinniped predators and adequate forage

PROPOSED ACTION COMPONENTS SPECIFIC TO LCR STEELHEAD

The Proposed Action, continuing to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2 of this document. Chapter 2 also provides details about the additional non-operational conservation measures for ESA-listed salmon and steelhead. LCR steelhead are exposed to the Proposed Action in the following ways:

- streamflow quantity and TDG changes from the Dalles Dam through the Bonneville pool and to the ocean.
- passage through Bonneville Dam in both the downstream and upstream migrations.

Non-operational conservation measures of the Proposed Action include structural measures, conservation hatchery programs, predation management, and habitat improvement actions. Targeted RM&E to support adaptive management is part of many of these measures.

LCR steelhead are exposed to conservation measures through

- avian and pinniped predator management actions in at Bonneville Dam and in the estuary
- habitat improvements in lower Columbia River tributaries and the estuary.

Based on their overall findings, NMFS (2019) concluded the following in their 2019 BiOp:

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, any effects of interrelated and interdependent activities, 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.

EFFECTS OF THE ACTION ON LCR STEELHEAD

The effects of the existence of the dam and reservoir system, and current operations, are part of the baseline and are not considered effects of the Proposed Action. The main effects on LCR steelhead of continuing to operate and maintain the CRS are related to downstream and upstream passage through the CRS mainstem, possibly as far upstream as the John Day pool.

Effects include any delayed or latent mortality that may occur as a result of juvenile salmon passage at the dams. Improving juvenile and adult migration survival has been the focus of mitigation actions under past BiOps, and the benefits of these actions have been thoroughly documented [Corps et al. (2017a); Bonneville et al. (2018a), Appendix D]. These already-completed actions will continue to provide benefits in the future. The effects of the Proposed Action on this ESU and its critical habitat are described by life-stage below.

Both juvenile and adult LCR steelhead from all populations will be exposed to the continuing effects of the Proposed Action in the mainstem Columbia River (Bonneville Pool) and estuary. The populations that migrate above Bonneville Dam (Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run populations) will also be exposed to the habitat effects described above, as well as to changes in operations at Bonneville Dam, and possibly at The Dalles and John Day Dams.

Freshwater Spawning, Rearing, and Migration to the CRS

In the spawning and rearing areas, LCR steelhead are not exposed to the effects of the CRS because no operations (e.g., flood risk management, irrigation, power generation) occur in these areas. Because there is no exposure to these operations that are components of the Proposed Action, there are no direct effects on individual fish in these areas.

Some individual fish of this ESU may be exposed to improvements in the tributary habitat component of the Proposed Action. Improvement projects have primarily focused on the interior Columbia River Basin, however, if projects occurred in the lower Columbia River Basin, LCR steelhead would benefit from

improved water quality and quantity, cover/shelter, food, riparian vegetation, or space that would result from the tributary actions. Adverse effects on individuals from actual implementation (i.e., construction) of habitat enhancement actions are mitigated through compliance with the HIP (Habitat Improvement Program) BiOp (NMFS 2013; USFWS 2013).

Juvenile Downstream Migration Through the CRS

Recent passage improvements improved 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). Based on a 2010 steelhead passage and survival study, NMFS estimated that 96.9 percent of juvenile steelhead that migrate past Bonneville Dam will survive (NMFS 2019). Juvenile LCR steelhead from those populations are exposed to the effects of CRS operations once they reach the mainstem Columbia River and pass through Bonneville Dam to the estuary. In this migration corridor, juvenile LCR steelhead will continue to experience the deleterious impacts of a degraded environmental baseline and associated cumulative effects.

In general, the Proposed Action will continue operations and implement actions to minimize impacts on and increase survival of juvenile LCR steelhead that pass through Bonneville Dam. Measures that have been implemented and will continue, include flow augmentation, spill, reduction of passage through turbines (e.g., through spill, surface passage and other juvenile bypasses), safer turbine passage, and predator management.

Changes in the Proposed Action compared to past operations include a flex spill operation and changed implementation of summer spill. Because juvenile LCR steelhead do not migrate during the summer, any changes in summer spill will not affect this ESU. Changes in spring spill could result in an increased juvenile passage survival for LCR steelhead that are passing through the CRS.

Juvenile Estuary Migration and Rearing, Including the Plume

Estuarine and nearshore ecosystems provide habitat in which juvenile LCR steelhead can forage and avoid predators. For example, most yearling salmonids tend to move through the estuary in 1 or 2 days, and survival in this reach appears to be high (Daly et al. 2014), excluding mortality associated with avian predation. The estuary is the final stretch of the Columbia, where all outmigrating juvenile salmon and steelhead species affected by the CRS transition from freshwater to ocean conditions.

This ESU may be exposed to estuary improvement actions, and may also benefit from the increased capacity and quality of estuarine ecosystems. Increasing the accessibility, capacity, and quality of estuarine ecosystems provides the final opportunity for juvenile salmon to grow and improve their condition before entering the ocean.

Operation of the CRS has led to changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, the effects of CRS water management in the estuary are generally attenuated below Longview, WA because of the distance from the facilities and inflow from tributaries like the Willamette and Cowlitz Rivers. Thus, any direct impacts from flow or elevated TDG in this area are expected to be minor. Proposed changes in water management are not expected to

substantially change flows downstream of Bonneville Dam, and therefore, the factors that currently influence fish travel time to the estuary are not likely to change.

The effects of CRS operations on populations originating in subbasins downstream of Bonneville Dam (19 out of 32 populations) 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 (NMFS 2019).

Avian predation continues to be a serious issue in the estuary. Previous management actions, like modifying nesting habitat to relocate colonies away from known high predation areas, have reduced the impact of avian predation. Continuing avian predator management in the estuary will benefit this ESU by reducing the number of individuals of this ESU eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1].

Ocean Rearing

LCR steelhead typically spend 1 to 2 years maturing in the ocean. During ocean residence, mortality of anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2019). The Proposed Action will have no effect on the marine habitats used by LCR steelhead for growth and maturing because there are no CRS operations that affect this area.

Adult Migration to and through Bonneville Dam

CRS operations generally result in negligible changes in flow and TDG levels in the estuary. It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River because of the distance from the facilities and the streamflows from lower river tributaries like the Willamette River. The Proposed Action causes no adult migration barriers for LCR steelhead adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. Thus, the Proposed Action is likely to have negligible effects on adult migration from the ocean to the CRS.

Adult LCR steelhead from Columbia Gorge populations use fish ladders to swim past Bonneville Dam, and possibly past The Dalles and John Day Dams, on their way to the spawning grounds. As noted above, the 5-year average of LCR steelhead detections is 296 adults at Bonneville Dam, 10 adults at The Dalles Dam, and <1 at McNary Dam. 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 98.5 percent (adjusted for harvest and straying) (NMFS 2019). Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life-stages such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations.

Adult Migration Upstream of the CRS to the Spawning Areas

After migrating upstream through the CRS, adult LCR steelhead begin to migrate to their natal streams. Once they enter those tributaries, they are no longer exposed to the operation and related effects of the CRS. Within these tributary habitats, a variety of non-operational actions have been implemented by the Action Agencies to benefit this ESU.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

The effects on critical habitat were assessed based on the elements of the Proposed Action that are likely to affect the PBFs essential for the conservation of the LCR coho salmon ESU (Table 3-57). Effects on designated critical habitat include the Proposed Action and associated mitigation that affect habitat within tributary spawning and rearing areas, the freshwater migration corridor, and estuarine areas.

Implementation of the Proposed Action is likely to affect passage at Bonneville Dam for 2 of the 24 populations. 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. The PBFs that could be affected by the Proposed Action are described in Table 3-57.

Table 3-57. Effects of the Proposed Action on the physical and biological features essential for the conservation of the LCR steelhead DPS [adapted from NMFS (2019); Table 2.6-6; Page 216].

Physical and Biological Feature (PBFs)	Effects of the Proposed Action
Freshwater spawning sites	The Proposed Action will continue the inundation of spawning habitat for steelhead in the lower reaches of the tributaries to the Bonneville Pool. No changes are expected in rearing sites.
Freshwater rearing sites	Juvenile LCR steelhead rear in the mainstem Columbia River. This PBF is negatively affected by morphological changes in the river and continued disconnection from floodplain habitat, which can affect food supply and supply of resting habitat.
Freshwater migration corridors	<p>Increased levels of total dissolved gas (TDG; water quality) in the gorge area during spring spill up to 120–125 percent could affect the conservation value of the habitat within Bonneville Reservoir and at least 35 miles downstream. This area serves as critical habitat for the Gorge Summer and Winter MPGs and one population in each of the Cascade Summer and Winter MPGs. Smolts are able to use behavioral mechanisms to avoid elevated TDG (i.e., by migrating deeper in the water column).</p> <p>Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the smolt outmigration, which could affect the safe passage PBF by increasing the risk of predation.</p> <p>The migration corridor is affected by passage at Bonneville Dam for the four populations that pass the dam. Passage conditions for adults (increased fallback) and for juveniles (increased spill passed fish versus reduced turbine passage [worse route] and reduced juvenile bypass system or corner collector passage [better route]) and could, potentially negatively affect survival, resulting in reduced conservation value of this PBF.</p>
Estuarine areas free of obstruction and excessive predation, with adequate water quality and salinity	<p>This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during implementation of the 2019 Proposed Action.</p> <p>Because estuary bird colonies and predation rates are in flux, it is not clear whether the continued tern and cormorant colony management is likely to continue any existing survival benefits; thus, we expect this PBF to remain unchanged.</p>

SUMMARY

The effects of the Proposed Action are summarized in Table 3-58, where the effects of the Proposed Action are compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action. Most of the actions are anticipated to either have no effect, or a positive effect compared to the current condition (Table 3-58). Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-58. Summary comparison of the Proposed Action to current conditions for LCR steelhead by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration
	Dam passage (adults; includes fallback and overshoot)		x	+	Potential positive effect from continued tributary habitat restoration (reducing temperature)
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Chinook Down-stream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x		+	Continuation of predator management programs should decrease predation.
	Hatcheries	x		=	
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Juvenile Chinook Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Chinook Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
Fish status and trend monitoring		x	=		

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Adult Chinook Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce overshoot and/or fallback.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Chinook Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Predation monitoring				Not applicable
	Fish status and trend monitoring		x	=	

3.1.5.4 Columbia River Chum Salmon

STATUS OF THE COLUMBIA RIVER CHUM SALMON ESU

This section examines the status of the Columbia River (CR) chum salmon ESU, the status of CR chum salmon critical habitat, and the effects of the Proposed Action on CR chum salmon and its critical habitat.

The CR chum salmon ESU was first listed under the ESA on March 25, 1999, at which time it was classified as a threatened species (64 FR 14508 1999). That status was reaffirmed on April 14, 2014. Critical habitat was designated on September 2, 2005 (70 FR 52746).

The status of a species is based on an assessment of extinction risk and is a function of abundance, productivity, spatial structure, and diversity; this assessment describes the species' potential for survival and recovery. The parameters listed above are, in part, included in listing decisions, status reviews, and recovery plans. The most recent status review used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis. Recent status reviews of the CR chum salmon by NMFS, suggest the ESU as a whole still warrants a threatened status (NWFSC (Northwest Fisheries Science Center) 2015). The status of the critical habitat within the designated range is based on the functionality of the PBFs that are used to develop the conservation value (NMFS 2019). A brief summary of the current status of CR chum salmon is provided below.

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 3-25), as well as two hatchery programs (NMFS 2019). The ESU spans 17 historical populations in three distinct ecological regions: Coast, Cascade, and Gorge (Table 3-59). Each of these three ecological regions is considered an MPG²⁵. Of the 17 historical populations, 14 are extirpated or nearly so (Ford 2011); there have been occasional reports of a few fish only. Only the Grays River and the Lower Gorge populations have consistently maintained natural spawning (Ford 2011). The only population that passes a CRS dam (Bonneville Dam) is the Upper Gorge population.

²⁵ The Willamette–Lower Columbia Technical Recovery Team 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 Interior Columbia Technical Recovery Team. For consistency, NMFS uses the term *major population group* in its BiOp, and we will do so here.

In their most recent 5-year status review of CR chum salmon(NWFSC (Northwest Fisheries Science Center) 2015), NMFS concluded that only 3 of 17 populations are at or near their recovery viability goals, although, under the recovery plan scenario, these 3 populations are those that have very low recovery goals of zero. The remaining populations generally require a higher level of viability, and most require substantial improvements to reach their viability goals.

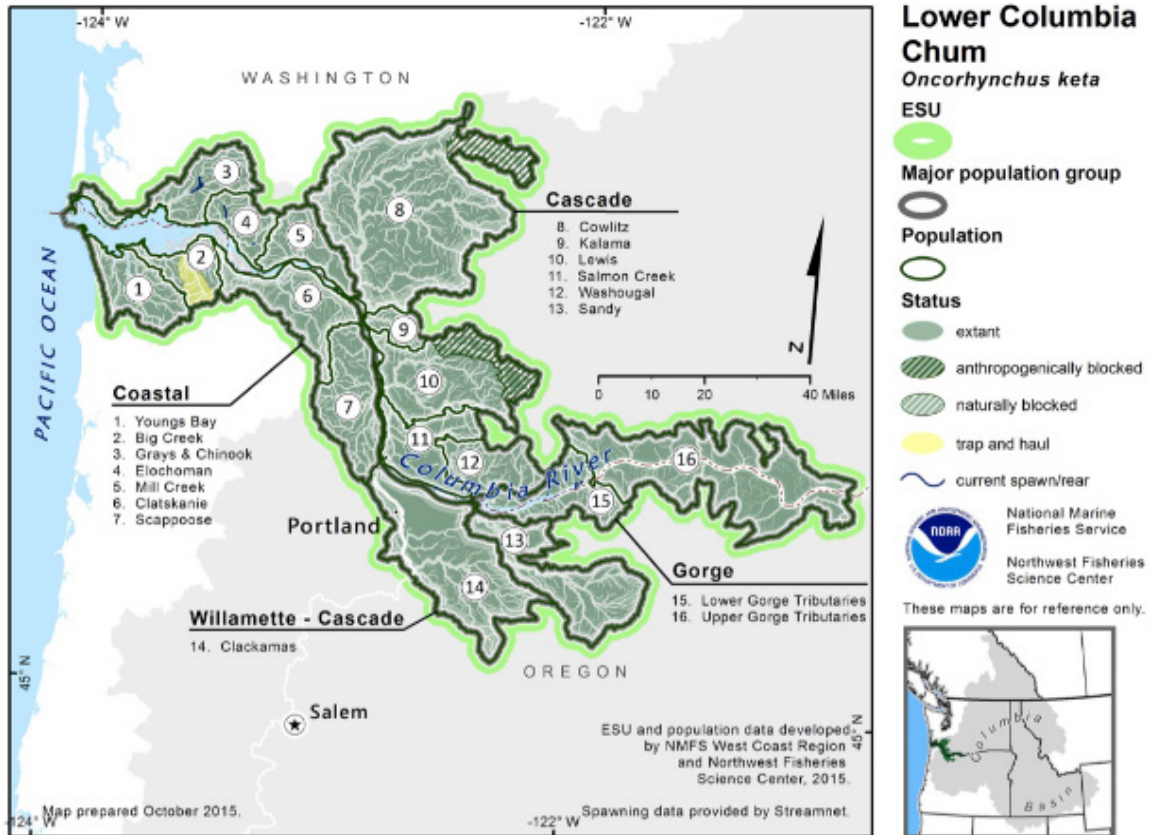


Figure 3-25. Map of the Columbia River chum salmon ESU's spawning and rearing area, illustrating demographically independent populations and major population groups [reproduced from NWFSC (Northwest Fisheries Science Center) (2015)]

Table 3-59. Columbia River chum salmon MPGs, run timing, and populations [Data from NMFS (2019)]

MPG	Run Timing	Population
Coast Range	Fall	Youngs Bay (OR)
		Grays/Chinook Rivers (WA)
		Big Creek (OR)
		Elochoman/Skamokawa creeks (WA)
		Clatskanie River (OR)
		Mill, Germany, and Abernathy creeks (WA)
		Scappose River (OR)
Cascade Range	Summer	Cowlitz River (WA)
	Fall	Cowlitz River (WA)
		Kalama River (WA)
		Lewis River (WA)
		Salmon Creek (WA)
		Clackamas (WA)
		Sandy (OR)
		Washougal (WA)
Columbia Gorge	Fall	Lower Gorge (WA & OR)
		Upper Gorge (WA & OR)

Based on their overall findings, NMFS concluded the following in their 2019 BiOp:

... Even with the improvements observed during the last five years, the majority of natural populations in this ESU remain at a high or very high risk category, and considerable progress remains to be made to achieve the recovery goals (NWFSC (Northwest Fisheries Science Center) 2015).

FACTORS AFFECTING THE STATUS OF CR CHUM SALMON

Within the mainstem Columbia River and its tributaries that support the spawning and rearing of CR chum salmon populations, a variety of limiting factors affect the species and their habitat. Processes such as climate change have altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, forestry practices and human development, including mainstem and tributary dams. Impacts associated with those activities include impaired tributary fish passage and degraded freshwater habitat, including reduced floodplain connectivity and function, degraded channel structure and complexity, reduced riparian areas and large woody debris recruitment, reduced streamflow, and reduced water quality (NMFS 2019).

Factors that occur during other life phases of the CR chum salmon also have profound impacts on the status of the species and include predation, adverse mainstem Columbia River hydropower-related effects, and degraded ocean conditions (NMFS 2019).

With a decline in salmonid production, and as a result a decline in spawners within natal streams, nutrients vital to juvenile production have also decreased dramatically. Gresh et al. (2000) estimated that since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only about 6–7 percent of historical levels. They attributed this decline to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. These nutrients are important for salmonid production, and consequently for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2000).

The length of residency and associated mortality with CR chum salmon by life-stage illustrates that for CR chum salmon, the greatest incidence of mortality occurs where these fish spend most of their life (i.e., ocean residence). However, freshwater mortality through predation can be substantial before chum salmon get to the ocean. Salo (1991), citing studies from Russia, British Columbia, and Washington State, suggests that in some systems, predation averages nearly 50 percent within the freshwater environment. However, mortality early after entry into the ocean can be substantial as well. Quinn (2005) citing studies in Puget Sound and the Sea of Japan, suggests mortality of chum salmon after ocean entry ranges from 9 to near 50 percent per day.²⁶

There are no estimates of passage survival through the CRS for this ESU because the majority of the ESU spawns in the Columbia River downstream of Bonneville Dam, and the size of downstream migrants is too small to tag.

Below, we discuss factors affecting the status of CR chum salmon by life stage.

Freshwater Spawning and Rearing

Chum salmon typically spawn in low-gradient mainstem and tributary reaches. In many areas, these habitats have been practically eliminated through a combination of channel alteration and sedimentation attributable to dams, forest and agricultural practices, residential and urban development, and gravel extraction (NMFS 2013). While many of the habitat modification are relics of past anthropogenic practices, NMFS (2019) identified factors limiting the viability of CR chum salmon that continue to influence productivity. The ESU is limited by one or more of the following factors: (1) reduced access to spawning and rearing habitat; (2) land development, especially in the low-gradient reaches that chum salmon prefer; (3) an altered flow regime and Columbia River plume; (4) reduced access to off-channel rearing habitat; (5) reduced productivity resulting from sediment and nutrient-related changes in the estuary, and (6) contaminants.

The consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. The ISAB (2015) provided evidence for strong density dependence at current abundance levels for anadromous salmon and steelhead and suggests that habitat capacity has been greatly diminished. Density dependence was observed in most rivers where data have been examined and includes 26 of 28 interior Columbia River Basin Chinook salmon populations, and in all 20 interior Columbia River Basin steelhead populations, despite natural spawners being much less abundant currently relative to historical abundance (ISAB 2015).

In an assessment of density dependence using a two-stage Gompertz model, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages, and concluded that due to density dependence during the parr-to-adult stage, a greater number of fish

²⁶ Quinn (2005) suggests that even the lower rates of mortality reported by investigators could not be maintained for long before the total collapse of the population, and suggests the studies may have been biased because of various violations of assumptions in the methodology. Regardless, the estimates indicate substantial mortality after chum salmon enter the ocean.

reaching the ocean may not substantially increase the number of adults reaching the spawning grounds. Based on this evidence, the authors concluded the following:

This suggests that life cycle modeling to date has been overly optimistic about the benefits of survival rate increases in the hydrosystem and elsewhere to improve the viability of salmon populations threatened with high extinction risk.

While the modeling framework of Hinrichsen and Paulsen (2019) was applied to SR spring/summer Chinook, the results are consistent with the 2015 ISAB report, and therefore it is reasonable to assume that once abundance increases, CR chum salmon may experience similar effects of density dependence.

Past and present effects of the existence of CRS dams and operations: CR chum salmon are exposed to the CRS facilities or operations during adult holding, spawning, egg incubation, and juvenile rearing and migration. Water flow management practices have reduced access to spawning and incubation habitat at higher elevations around the Ives/Pierce Island complex in the Bonneville Dam tailrace, which is a major spawning area for CR chum salmon. In addition, past flow management had the potential to dewater redds in the mainstem Columbia River (NMFS 2019). The Action Agencies provide a tailwater elevation at Bonneville Dam each year that supports chum spawning during late fall and winter and incubation in the Ives Island complex into spring. This typically requires flow augmentation from storage reservoirs before reliable flow forecast information becomes available.

Past effects of hatcheries: Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They can also help preserve genetic resources until factors limiting natural productivity can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of risk depends on the status of affected populations and the specific practices in the hatchery program.

Because the demographic risk is so high (because the abundance of spawners is so low for this ESU), potential risks associated with hatchery programs are outweighed by the abundance increase in spawners that the hatchery programs are expected to produce (NMFS 2019). NMFS (2019) concluded:

At this stage, demographic concerns outweigh any risk posed by hatchery-induced selection, so no Proportion of Hatchery-origin fish on the Spawning Grounds (pHOS) / Proportionate Natural Influence (PNI) standards 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.

Juvenile CR Chum Salmon Downstream Migration Through the CRS

As discussed previously, the CR chum salmon ESU consists of the three MPGs, and most of the ESU originates downstream of Bonneville Dam. The population that originates upstream of Bonneville Dam migrates through one CRS project (Bonneville Dam) to and from the Pacific Ocean.

Past and present effects of CRS existence and operations: Juvenile CR chum salmon have been and continue to be exposed to the effects of both CRS operations and the existence of Bonneville dam. The dam (Bonneville) that juvenile CR chum salmon must pass is part of the environmental baseline. During their downstream migration, CR chum salmon have the opportunity to pass the dam by many routes.

Routes of passage include spillways and surface passage structures, JBSs, and turbine units. In each case, passage is supported by components of CRS operations that are designed to mitigate the passage impediments caused by the existence of the dams. Major modifications have been made to baseline conditions within the CRS to improve survival and achieve the 2008 BiOp juvenile dam passage performance standards of 96 percent for spring migrants and 93 percent for summer migrants at each project.

Past modifications of the dams to improve baseline conditions include the installation of surface passage systems, improved turbine designs, and upgrades of screened bypass systems to improve how and where fish are returned to the river downstream from dams, as well as new spill operations tailored to the unique structural configuration of each dam (Bonneville et al. 2018b). A summary of the improvements is provided by Bonneville et al. (2018a), Appendix A, and is incorporated by reference here. The actions that have benefitted CR chum salmon during this life stage include the following:

- Change operations to minimize winter drafts of the large upper basin storage reservoirs (for flood risk management and power generation) to save water for augmenting spring flows during the peak juvenile passage period (water quantity).
- Construct JBSs and surface passage structures and provide spill at the run-of-river dams to divert smolts away from turbine units (safe passage) and reduce potential delay in the forebays.
- Install safer turbines for fish passage.
- Reduce TDG through multiple actions and plans.
- Manage avian and fish predators through multiple actions and plans.

As discussed previously, because juvenile chum that pass downstream past Bonneville Dam are too small to tag, there are no estimates of passage survival for this ESU.

In addition, TDG levels affect water quality in the mainstem Columbia River. Atmospheric gases can be forced into solution when water passes over the spillway at a mainstem dam, either as part of CRS operations or involuntarily due to high inflows, which can cause downstream waters to become supersaturated. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death. Historically, GBT was a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019).

Past effects of predator management: Survival of juvenile CR chum salmon is affected by avian and native and non-native fish predators that inhabit the mainstem Columbia River. The 2008 FCRPS BiOp required that the Action Agencies implement multiple predation control measures to increase the survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. These efforts have reduced avian and piscivorous predation on juvenile salmon at the dams (NMFS 2019).

Juvenile CR Chum Salmon Estuary Migration and Rearing, Including the Plume

The estuary provides important migratory habitat for CR chum salmon populations. Since the late 1800s, 68 to 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening [Kukulka and Jay (2003); Bottom et al. (2005); and Marcoe and Pilson (2017) as cited in NMFS (2019)]. Disconnection of tidal wetlands and floodplains from the mainstem river has reduced the production of wetland detritus and macroinvertebrates supporting salmonid food webs in wetlands and the mainstem [Simenstad et al. (1990); Maier and Simenstad (2009); and ERTG (2019) as cited in NMFS (2019)]. Flow regulation and mainstem channel modifications have also affected estuary ecosystems. For a more detailed discussion of estuary and plume conditions, see (NMFS 2019). All of these conditions are part of the environmental baseline.

Past and present effects of CRS existence and operations: While there are no CRS facilities in the estuary, past operations of CRS dams affected the timing and volume of flows, as well as water quality in this area. However, the influence is generally attenuated below Longview, WA because of the distance from the dams, inflow from other tributaries joining the Columbia River, and multiple other dams and diversions within the basin that also affect flows and water quality in the estuary. The reduction in flows and associated sediment recruitment downstream from Bonneville Dam, have likely limited the occurrence of some downstream habitat forming processes.

Estuarine floodplain habitat is important for outmigrating juvenile salmon and steelhead, including CR chum salmon. To help maintain and improve the overall status of salmon and steelhead in the Columbia River Basin, the Action Agencies actively work to restore and conserve habitat in the Columbia River estuary through the CEERP. The CEERP restoration actions affect salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit of estuary restoration is that wetland food production supports foraging and growth within the wetland [Johnson et al. (2018) as cited in NMFS (2019)]. Prey items (primarily chironomid insects and corophiid amphipods [PNL/NMFS (2018) as cited in NMFS (2019)]) produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest 5-year review of the CEERP, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide-gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity below Bonneville Dam [Johnson et al. (2018) as cited in NMFS (2019)]. In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past effects of predation management: A variety of avian species (especially Caspian terns and double-crested cormorants), have historically been a major source of predation on juvenile salmonids in the estuary. While avian predators continue to prey upon juvenile salmonids, including CR chum salmon, predation rates have declined because of a variety of management efforts. There are no estimates of predation on juvenile CR chum salmon in the estuary because of the size of CR chum salmon juveniles entering the estuary, and the methodology for determining predation rates of fish from birds (recovery of PIT tags; no juvenile CR chum salmon have been PIT tagged). NMFS (2019) has noted the success of

implementing the avian management plans at meeting underlying goals, but the results may be uncertain at this time because avian predators have relocated to other areas within the estuary.

Ocean Rearing

CR chum salmon typically spend 2 (primarily) or 3 years rearing in the ocean (Johnson et al. 1997). Variability in marine ecosystem productivity can be the major factor determining adult CR chum salmon run size (NMFS 2014a). In the most recent adult return years since about 2014, abnormally warm ocean temperatures and subsequent poor ocean conditions have contributed to declines in ocean survival and associated adult returns. In the 2019 BiOp, NMFS provides a detailed discussion of ocean conditions, factors that affect the ocean environment, and impacts on CR chum salmon; that information is incorporated here by reference. A brief summary of those factors is provided below.

Factors that influence ocean productivity are also likely to affect survival of CR chum salmon. Factors that affect survival, either directly or indirectly, because of their deleterious impacts on marine food webs, include climate change, severe El Niño events, ocean acidification, and major alterations in the northeast Pacific marine ecosystem associated with the PDO (NMFS 2019).

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in marine distribution. Many species that typically only occur in more southerly waters, moved northward from southern California to Alaska during the unusually warm water in 2014 and 2015, which was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Percy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt the marine ecosystem in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean and past CRS operations have had no direct effect on this ESU during ocean residence. In a recent review, Welch et al. (2018) concluded that marine survival of West Coast Chinook and steelhead populations has collapsed over the last half century for most regions of the West Coast. Based on their review of annual survival estimates for Chinook and steelhead, they concluded the following:

We found that marine survival collapsed over the past half century by a factor of at least 4-5 fold to similar low levels (~1%) for most regions of the west coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Another factor that should be considered is delayed, or latent, mortality. Delayed mortality is a term for harm caused when an animal survives one event or circumstance, but incurs damage that only shows up later and may be expressed as illness or death. With Columbia River Basin salmon and steelhead, the term is commonly applied in situations such as barging or dam passage of salmon or steelhead smolts. The term “latent mortality” is generally used more specifically to apply to the effects of dam passage. While most or all of the fish might survive the act of barging or safely pass the dam, the delayed

mortality hypothesis holds that a smolt is less healthy than it would be otherwise and therefore less likely to survive in the ocean and return as an adult.

After reviewing various studies, the ISAB (2012) concluded that fish bypass systems are associated with some latent mortality, but the factors responsible for latent mortality remain poorly understood and are inadequately evaluated. Further:

The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis).

Past effects of harvest: Chum salmon are not targeted by ocean fisheries, and the Pacific Fisheries Management Council has stated the ocean fisheries have no measurable effect upon chum salmon (PFMC 2019).

Adult CR Chum Salmon Migration to Bonneville Dam

Adult CR chum salmon migrating upstream after ocean residence typically do not feed in the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume, and a migratory corridor free of obstructions to access spawning areas (NMFS 2019). Adult CR chum salmon enter the Columbia River near the end of October and are present in the vicinity of the Bonneville Dam tailrace during November and December.

For upstream migrating CR chum salmon, the primary factor affecting survival in the Columbia River to the Bonneville Dam and downstream, is pinniped predation. California and Steller sea lions prey on adult CR chum salmon throughout the lower Columbia River. The ODFW has documented an increase in the monthly counts of California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, during the month of September. For the years of 2008 to 2014, the number of California sea lions observed averaged less than 500 animals; for 2015 and 2016 that average increased to more than 1,000 individuals (NMFS 2019).

Past and present effects of CRS dams and operations: There are no CRS dams that impede migration in the lower Columbia River as these fish migrate upstream to the vicinity of Bonneville Dam. As previously mentioned, adult CR chum salmon enter the Columbia River at the end of October, and therefore, while the Action Agencies are required to spill water over the CRS dams to increase survival of juvenile fish migrating downstream, the timing of doing so does not coincide with CR chum salmon migration in the lower Columbia River. So, adults will not be exposed to higher levels of TDG, which could influence their migration behavior or increase their chances of getting GBT (NMFS 2019). However, TDG levels are mitigated to some extent downstream from Bonneville Dam by gas dissipation and mixing of water with lower TDG levels from tributaries such as the Willamette River. Furthermore, with the exception of the one population that spawns upstream of Bonneville Dam, none of the other populations in this ESU pass any of the mainstem CRS projects (NMFS 2019).

Past effects of harvest: Harvest mortality in fisheries downstream of Bonneville Dam has been reduced substantially in response to evolving conservation concerns and harvest restrictions for ESA-listed

species. Historically, CR chum salmon were harvested in both non-treaty and treaty commercial fisheries, as well as in recreational fisheries. However, because of substantially reduced abundance, there is no directed harvest of CR chum salmon. Commercial harvesters in the lower Columbia River have taken fewer than 100 fish per year since 1993, and all recreational fisheries have been closed since 1995. The overall exploitation rate has been less than 1 percent in recent years.

Adult CR Chum Salmon Migration Through CRS Dams

As previously stated, only one population of the CR chum salmon ESU migrates past Bonneville Dam. In the 2019 BiOp, NMFS stated the following:

Adult chum salmon counts in the ladders at Bonneville Dam have ranged from 17 in 2000 to 411 in 2003, averaging 107 adults per year. The most recent 10-year average (2008–17) is 96 adults (McCann 2018), which is similar to the 107 adults mentioned above as the average number of adults moving upstream of Bonneville Dam between 2013 and 2017 based on dam counts. NMFS (2008a) estimated that the adult passage mortality rate for chum salmon at Bonneville Dam was similar to that of SR fall-run Chinook salmon, which are present during the same time period (about 3.1 percent). Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

Adult CR Chum Migration Upstream of the CRS to the Spawning Areas

Within the tributaries that support the spawning and rearing of CR chum salmon, a variety of limiting factors affect the species and their habitat. Processes such as climate change have altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (1) impaired fish passage; (2) reduced stream complexity and channel structure; (3) excess fine sediment; (4) elevated summer water temperature; (5) diminished streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

Low flows and high summer temperatures in tributary habitats can effectively create temporary migration barriers that reduce access to spawning habitat until conditions improve. These water quality conditions in tributary habitats can affect the run timing and survival to natal spawning areas for adult CR chum salmon.

Past effects of predator management: For the population that spawns upstream of Bonneville Dam, there are no predator issues, but, as discussed previously, pinniped predation downstream of Bonneville Dam can be substantial.

Past effects of harvest: As stated previously, there are no directed fisheries for CR chum salmon.

STATUS OF CRITICAL HABITAT

In this section of the BA, the status of critical habitat is reviewed for CR chum salmon. Critical habitat includes the stream channels within designated stream reaches and to an extent is defined by the ordinary high-water mark (33 CFR § 319.11). The PBFs of critical habitat that are essential to the conservation of CR chum salmon include freshwater spawning, rearing and migration corridors, as well as estuarine and nearshore marine areas (Table 3-60) (NMFS 2019).

Critical habitat for CR chum salmon was designated on September 2, 2005 (70 FR 52630). Critical habitat for CR chum salmon encompasses six subbasins in Oregon and Washington, as well as the Columbia River from its mouth to the confluence with the White Salmon River, approximately 22 river miles upstream of Bonneville Dam. The PBFs of that critical habitat essential for the conservation of the species are presented in Table 3-60.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation 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 CR chum salmon.

Table 3-60. Physical and biological features of designated critical habitat for Columbia River chum salmon [From NMFS (2019)]

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline 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) Loss of wetland and side channel connectivity in the estuary (channel manipulations, diking, wetland conversion, stream clearing, gravel extraction) Excessive sediment in spawning gravel (unimproved roads, forest and agricultural practices in upstream watersheds) Inundation of spawning sites in the lower ends of tributaries under Bonneville Reservoir (hydrosystem development)
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 upwelling areas of clean gravel beds in the estuary through channel alteration and sedimentation (forest management, agriculture, rural residential uses, urban development, and gravel extraction) Loss of wetland and side channel connectivity in the estuary (channel manipulations, diking, wetland conversion, stream clearing, gravel extraction) Excessive sediment in streambed (unimproved roads, forest and agricultural practices in upstream watersheds)
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	Delay and mortality of some juveniles and adults Concerns about increased opportunities for pinniped predation in mainstem spawning areas below Bonneville Dam
Estuarine areas	Free of obstruction and excessive predation; 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
Nearshore marine areas ^a	Free of obstruction and excessive predation; water quality, quantity, and forage	Concerns about increased opportunities for pinniped predators, adequate forage

^a Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

PROPOSED ACTION COMPONENTS SPECIFIC TO COLUMBIA RIVER CHUM SALMON

The Proposed Action, to continue to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2 of this document and associated appendices as modified by the flex spill Letter to NOAA. Reclamation is also consulting on the Columbia River mainstem effects of six irrigation projects that also have additional and separate ESA reviews.²⁷ This Proposed Action continues extensive operations that benefit CR chum salmon, including flow augmentation. In addition, mitigation activities that have been implemented as part of previous BiOps will continue, including estuary habitat improvements and fish, avian, and pinniped predator management, as described in Chapter 2 of this document. The Action Agencies will continue to coordinate with regional sovereigns and will regularly update the water management, fish passage, fish operations, and water quality plans. The Action Agencies intend to implement these actions commencing in September 2020 and continuing until a regulatory re-initiation of consultation trigger is met.

Columbia River chum salmon are currently exposed to CRS operations

- streamflow management and TDG changes from The Dalles Dam to the ocean
- modification of the serpentine weir at Bonneville Dam.

EFFECTS OF THE ACTION ON CR CHUM SALMON

The effects of the existence of the dam and reservoir system, and past operations, are part of the baseline and are not considered effects of the Proposed Action. Already-completed mitigation actions will continue to provide benefits in the future. The effects of the Proposed Action on this ESU and its critical habitat are described by life stage below.

Freshwater Spawning, Rearing, and Migration to the CRS

In the spawning and rearing areas, chum salmon that spawn in the mainstem Columbia River are exposed to the effects of the CRS, but fish that spawn in the tributaries are not. Fish that spawn in the mainstem Columbia River are exposed to the potential effects of the CRS operations during adult holding, spawning, incubation, and juvenile rearing.

Bonneville has funded tributary actions within the range of chum salmon. Some of these actions were targeted for CR chum salmon, while others were implemented for other anadromous salmonids and should also benefit chum salmon.

²⁷ Columbia River mainstem effects of certain Reclamation irrigation projects are included in this CRS consultation because the Columbia River hydrologic modeling incorporates all such impacts. The mainstem Columbia River impacts are included for the Yakima, Umatilla, Deschutes, and Crooked River irrigation projects. The flow impacts of these projects to the mainstem Columbia River are fully integrated in discussions of flow and TDG in the parts of the migratory corridor both used by this ESU and affected by these projects.

Juvenile CR Chum Salmon Downstream Migration Through the CRS

For CR chum salmon that spawn in the mainstem Columbia River, juveniles are exposed to the effects of CRS operations from their spawning areas to the estuary. Columbia River chum salmon populations that spawn in the tributaries are not exposed to the CRS until they enter the Columbia River. In the Columbia River mainstem migration corridor, juvenile CR chum salmon will continue to experience the deleterious impacts of a degraded environmental baseline and associated cumulative effects.

One population (Upper Gorge) spawns upstream of Bonneville Dam. Juveniles from this population pass downstream from Bonneville Dam during their seaward migration to the ocean. The survival of downstream migrants is likely to have improved in recent years because of the construction of the Bonneville Corner Collector and JBS at Powerhouse 2, as well as the increased percentage of flow approaching the dam that goes over the spillway.

A more detailed analysis of the effects of the Proposed Action on CR chum salmon is provided below. The indicators that will be used to determine the effects of the Proposed Action on juvenile CR chum salmon migration through the estuary and plume include the following:

Operational

Chum salmon only encounter one CRS project, Bonneville Dam, so none of the structural measures described in common effects for juvenile salmon and steelhead would apply to these fish, and only a small proportion of spawning occurs above Bonneville Dam. Because there is no direct estimate of Bonneville Dam project survival specific to juvenile chum, juvenile model metrics for SR spring/summer Chinook salmon are used as a surrogate to estimate any change in juvenile survival for the portion that pass Bonneville Dam. Under MO1 (multiple objective alternative 1), COMPASS modeling indicates that MO1 would be similar to the baseline, with a 1.2 percent increase in juvenile survival. For MO4, the COMPASS model estimates that survival would increase 0.6 percent (Table 3-61).

The results from the COMPASS model suggest that powerhouse passage will decrease about 16 percent with implementation of MO1 and 78 percent with implementation of MO4. TDG-related survival is reduced for MO1 by 0.4 percent and 16 percent for MO4 (Table 3-61).

Survival

Survival of juvenile salmonids in the Snake and Columbia Rivers is influenced by a suite of factors, such as water quality (e.g., temperature, TDG, turbidity), passage at hydro projects, predators, fish travel time, etc. Survival studies show, with few exceptions, that measures implemented through the previous BiOps, and continued into the current Proposed Action, performed as expected and have achieved, or are very close to achieving, the 2008 BiOp juvenile dam passage survival objectives (NMFS 2017e).

While juvenile passage survival through turbines is generally lower than spillway survival, bypass and sluiceway survival can be close to, equal to, or even greater than spillway survival in terms of direct dam survival. Because only one population of CR chum salmon spawns upstream of Bonneville Dam, the majority of the CR chum salmon ESU will not pass Bonneville Dam, and therefore, the impacts on migrating juveniles is not nearly as substantial as on other upstream ESUs.

As discussed previously, survival of CR chum salmon is influenced by CRS operations. Flow management for CR chum salmon adult spawners and during incubation is an important component of increasing the survival of this ESU. In addition, for CR chum salmon juveniles that are produced upstream of Bonneville Dam, the proposed increased spring spill will likely result in higher proportions of juveniles passing downstream via the spillway than via the juvenile bypass or corner collectors, and exposure to increased levels of TDG below Bonneville Dam, if they are still present when the flex spill program begins in April.

Table 3-1. Relevant juvenile model metrics for SR spring/summer Chinook salmon used as a surrogate for CR chum salmon

Metric (Model)	NAA 2016 Ops	MO1		MO4		Range
		Value	Change from NAA	Value	Change from NAA	
Juvenile Survival (COMPASS)	50.4%	51.0%	1.2%	50.7%	0.6%	0.6%
Juvenile Survival (CSS)	57.6%	58.3%	1.2%	63.5%	10.2%	5.9%
Powerhouse Passages (COMPASS)	2.3%	1.9%	-16.4%	0.5%	-78.2%	176%
Powerhouse Passages (CSS)	2.2%	1.7%	-19.1%	0.3%	-84.2%	181%
TDG-related Juvenile Survival	97.9%	97.5%	-0.4%	81.9%	-16.3%	16.0%

Exposure to TDG will increase for chum salmon fry that may still be present downstream of Bonneville Dam in April and May. Elevated TDG levels from the flexible spring spill operation (up to 120 or 125 percent TDG) will likely extend to approximately 35 miles downstream of Bonneville Dam. An increase in TDG exposure is not expected to substantially affect the species because the average exposure will be similar to what has been experienced in the baseline. Assuming recent water temperature conditions, the majority of chum salmon fry will likely have emerged and migrated to the ocean by the time spring spill begins on April 10 (NMFS 2019).

Fish travel time

Proposed changes in water management are not expected to substantially increase flows, and therefore, the factors that currently influence fish travel time are not likely to change.

Powerhouse passage proportion

Increasing the proportion of water discharged as spill directs a higher fraction of migrants away from the powerhouse and toward the less hazardous spillway. This reduces smolt encounters with turbines and screened bypass system, both of which have been hypothesized to contribute to latent mortality, which is expressed in the marine environment. It is also possible that reduction in powerhouse encounters results in reductions in latent mortality leading to increased survival during later life stage development in the estuary and marine environments. The models predict a potential decrease in powerhouse encounters [19% (COMPASS) to 84% (CSS)], which could benefit SR spring/summer Chinook salmon.

TDG levels

Spill at CRS dams can cause downstream waters to become supersaturated with dissolved atmospheric gases. This may occur during periods of high flows (involuntary spill) or purposely for set periods of time as a result of the Proposed Action. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids that may result in injury or death. Survival of juvenile salmonids can be reduced if TDG levels exceed lethal limits and fish are not able to compensate by swimming into deeper water (Beeman and Maule 2006).

Biological monitoring within the CRS shows that the incidence of GBT in migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 125 percent of saturation (Antcliffe et al. 2002; Backman et al. 2002; NMFS 2019). When those levels are exceeded, there is a corresponding increase in the incidence of GBT symptoms. McGrath et al. (2006) determined that newer research supports previous research indicating that short-term exposure to up to 120 percent TDG does not produce significant effects in juvenile (or adults) salmonids when compensating water depths are available (Beeman and Maule 2006; NMFS 2019). Therefore, it is anticipated that any increase in TDG as a result of implementing the flexible spill operation will result in negligible increases in GBT for outmigrating juvenile CR chum salmon through the CRS, because the Proposed Action is not intended to exceed the 125 percent “gas cap” during periods of voluntary spill. As mentioned previously, GBT was historically a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam. Gas abatement structures reduce the supersaturation of water by ensuring that water does not plunge to depth and force gas into saturation (NMFS 2019).

Temperature changes

Temperature changes can cause stress and mortality in CR chum salmon. Temperature influences growth and feeding rates, metabolism, development, migration timing, and the availability of food. In addition, temperature plays a role in predator fish behavior, which also affects juvenile salmonid survival.

Current temperature conditions are different from historical conditions as a result of a suite of anthropogenic activities (as described in the status of the species section). The Proposed Action is not anticipated to change the current temperature regime in the river during the time that CR chum salmon juveniles are outmigrating through the CRS. Therefore, it is anticipated that temperature changes attributable to the Proposed Action will likely be indistinguishable from current conditions and will result in negligible consequences to outmigrating juvenile CR chum salmon.

Turbidity

The existence of the CRS (and other non-federal dams) reduces sediment transport from historic levels, and subsequently reduces turbidity when suspended particles in the water fall out when the water enters a slower moving reservoir. These conditions are part of the environmental baseline. Lowered turbidity levels may increase the susceptibility of CR chum salmon to avian and piscivorous predators due to increased visibility in the water column. Implementing the Proposed Action is unlikely to alter the amount of suspended solids (and resulting turbidity) in the water column through the CRS. However,

while outmigrating juvenile CR chum salmon will continue to experience a less turbid system as a result of past actions, the Proposed Action does include measures to address these baseline conditions in the vicinity of the dams, as described in the next section (predation rates).

Predation rates

A variety of bird and fish predators consume juvenile CR chum salmon during their migration from rearing areas to the ocean. Existing conditions create habitat that is more ideal for native and non-native predatory fish. Outmigrating juvenile CR chum salmon encounter these predatory fish as they pass through the reservoirs and tailraces of the CRS. Implementing the Proposed Action will continue to reduce pikeminnow and avian predation on CR chum salmon. The Proposed Action will not otherwise change conditions in a manner that will substantially modify the environmental baseline conditions of the distribution or abundance of predatory piscivorous fish in the CRS. Thus, outmigrating CR chum salmon are anticipated to continue to be exposed to predation as they migrate through the CRS and estuary.

Efforts to minimize predation by birds and pikeminnow will continue with the Proposed Action. In 1990, the Action Agencies began a program to reduce predation by northern pikeminnow by removing them at the dams and initiating a sport reward program that pays anglers for pikeminnows removed (see NPMP below). 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. Avian dissuasion actions at the dams (e.g., wires, sprinklers, etc.) and in the estuary will continue with implementation of the Proposed Action. Collectively, these efforts are intended to continue to minimize predation rates on outmigrating juvenile salmon and steelhead.

Non-Operational

Predation management

Predation on salmon and CR chum salmon in the Columbia River Basin affects species survival and viability. Birds and native and non-native fish prey on juveniles as they pass through the hydrosystem. Direct predation occurs when hatchery-origin fish eat natural-origin fish; indirect predation occurs when predation from other sources increases as a result of the added abundance of juvenile salmon from hatchery releases.

Avian

The Action Agencies have developed various plans to help minimize predation by birds—a baseline condition influencing the survival and recovery prospects of CR chum salmon. In 2005, the Caspian Tern management plan was approved (USFWS 2005), and in 2014, the Inland Avian Predation Management Plan (IAPMP) began (Corps 2014a). These plans manage for avian predation on juvenile salmonids as they migrate to the ocean by redistributing bird nesting colonies in the estuary (USFWS 2005), or inland (Corps 2014a) to other nesting sites in the western U.S. Continued implementation of these plans in the Proposed Action will minimize predation by birds on juvenile salmonids.

While there are no estimates of predation on CR chum salmon, efforts to minimize predation by birds will continue with the Proposed Action. The flex spill program may also decrease predation in CRS dam

tailraces by increasing the turbulence downstream of the dams, making it more difficult for birds to locate and prey upon juvenile salmonids. The flex spill program may also reduce forebay predation at Bonneville Dam due to reduced passage delay.

Piscivorous fish

The northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River. In 1990, the Action Agencies began the NPMP (Northern Pikeminnow Management Program) to reduce predation by northern pikeminnow by removing fish at the dams, and began a sport reward program that pays anglers for pikeminnow caught in other parts of the mainstem Columbia and Snake Rivers. Williams et al. (2017) compared current northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent.

All predator management programs will continue under the Proposed Action and will continue to reduce the consumption of juvenile salmon and steelhead. Incidental catch of ESA-listed salmon and steelhead as a result of implementing the Pikeminnow Sport Reward Fishery and dam angling program has occurred in the past and is likely to continue at a similar rate in the future.

Juvenile CR Chum Salmon Estuary Migration and Rearing, Including the Plume

The estuary provides important rearing habitat for CR chum salmon. Estuarine and nearshore ecosystems provide habitat in which juvenile CR chum salmon can forage and avoid predators. Chum salmon use of the Columbia River estuary is more extended than use by yearling migrating salmonids. Weitkamp et al. (2012) found that juvenile chum salmon are in the estuary from 2 to 4 weeks.

Construction and operations of the CRS have led to changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, the effects of CRS water management in the estuary are generally attenuated because of the distance from the facilities and inflow from tributaries like the Willamette and Cowlitz Rivers. Thus, any direct impacts from flow or elevated TDG in this area are expected to be minor.

While there are no estimates of predation on juvenile CR chum salmon in the estuary, it is reasonable to assume that continuing avian predator management in the estuary will still benefit this ESU by reducing the number of individuals consumed by birds. Estuary habitat actions will continue, and this ESU will continue to benefit from this work.

Estuary Habitat Actions

As part of the Proposed Action, the Action Agencies will continue implementing the CEERP to improve estuarine habitat and tidally influenced portions of tributaries used by anadromous salmon and steelhead. The planned improvements in habitat functions are expected to provide long-term benefits to native species that use these habitats, through improved ecological function and processes. Appropriate ESA consultation is typically undertaken prior to implementation of these projects at the site-specific scale, and are complete with ITS and implanting Terms and Conditions with which the Action Agencies comply. Implementation of the Proposed Action will continue habitat restoration efforts that are benefitting juvenile salmonids. Project effectiveness is expected to increase over time as the juvenile salmonids mature and new measures are implemented.

Fish status and trend monitoring

One aspect of the CEERP involves monitoring the effectiveness of restoration actions and conducting research to address critical uncertainties. Adaptive management is used to guide program goals and actions (Johnson et al. 2018), and RM&E will continue under the Proposed Action. As illustrated above, the CEERP is benefitting salmonids, both in the juvenile and adult life-history stages.

Ocean Rearing

During ocean residence, mortality of anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2014a; U.S. v. Oregon 2018; NMFS 2019). Of the factors that influence ocean productivity, which have been linked to salmonid growth and survival, the most influential is the PDO. However, other processes, such as the NCC, the NPGO, the ENSO, climate change, and ocean acidification (NMFS 2019), also contribute to ocean productivity. All these factors will affect survival, directly or indirectly, because of their deleterious impacts on marine food webs.

The Proposed Action will have no effect on the marine habitats used by CR chum salmon for growth and maturing because there are no CRS operations that affect this area. However, a small number of individual salmon and steelhead will experience the range of deleterious effects from capture and handling related to Action Agencies-funded RM&E activities investigating salmon and steelhead in the nearshore ocean environment.

Adult CR Chum Salmon Migration to Bonneville Dam

While no indices of migration rate from coastal waters to spawning areas in the mainstem Columbia River or spawning tributaries exist for CR chum salmon, CR chum salmon are known to enter the Columbia River beginning at the end of October. Because of this timing, adult CR chum salmon will not encounter elevated levels of TDG from the Proposed Action. The Proposed Action causes no adult migration barriers for CR chum salmon adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower river tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. NMFS (2019) suggested that adult survival through Bonneville Dam is similar to SR fall-run Chinook salmon—approximately 97 percent. Thus, the Proposed Action is likely to have negligible effects on CR chum salmon adult migration from the ocean to spawning areas downstream and upstream of Bonneville Dam.

Operational

Travel Time

The Proposed Action is not expected to alter the migration rate of adult CR chum salmon in the lower Columbia River. While the Proposed Action will result in negligible flow reductions and water particle

velocity, the timing of adult CR chum salmon migration does not occur when this will be happening, and therefore, the effects of the Proposed Action are not expected to result in any increase or decrease in migration rate.

Total Dissolved Gas

The Proposed Action includes a flexible spill component, which during spring spill operations will result in spill at CRS projects to a level where the state water quality limit for TDG is met 16 hours per day, and the performance spill component will total 8 hours per day. As such, TDG levels will reach 120 percent of saturation during the 16-hour block, and a lesser amount during the performance spill component. Furthermore, it is anticipated that the gas cap of 120 percent for the 16-hour block will increase to 125 percent in 2020.

Elevated levels of TDG can increase the likelihood of GBT in adult and juvenile salmonids, which can injure or kill afflicted individuals. To offset the extent of gas supersaturation at CRS projects, the Corps has installed gas abatement devices in the spillways to reduce TDG levels.

However, because of the timing of CR chum salmon upstream migration from the end of October through December, the Proposed Action is not expected to have any effects on this ESU downstream from Bonneville Dam.

Temperature

Because actions associated with the Proposed Action will not result in elevated water temperatures, the effects of the Proposed Action are not expected to negatively affect adult CR chum salmon within this reach.

Turbidity

Because actions associated with the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam, the Proposed Action is not expected to negatively affect adult CR chum salmon within this reach.

Non-Operational

Predation

For upstream migrating adult CR chum salmon, the primary factor affecting survival to Bonneville Dam is pinniped predation. The existence of Bonneville Dam, which is part of the environmental baseline, likely causes pinnipeds to congregate downstream from that project. However, if Bonneville Dam were not present, the pinnipeds would likely congregate at Cascade Falls or other upstream falls, much like they do at Willamette Falls. Estimates of pinniped predation downstream of Bonneville Dam are not available for adult CR chum salmon, but salmonid consumption by California sea lions, Stellar sea lions, and harbor seals up to the tailrace of Bonneville Dam has been observed (NMFS 2019). In a study assessing pinniped predation on adult salmonids and other species, Tidwell et al. (2019) estimated a consumption rate of 0.7 percent for Chinook salmon during the fall period, when adult CR chum salmon are migrating.

Measures intended to reduce the baseline condition of predation on adult salmonids such as hazing, species removal, and the continued use of structures to physically exclude pinnipeds from entering the Bonneville Dam fishways (Sea Lion Excluder Devices and Floating Orifice Gates) will continue under the Proposed Action. No components of the Proposed Action are expected to result in a change from current conditions associated with pinniped predation.

It is anticipated that the Action Agencies will continue to implement the NPMP as well as the Sport Reward Fishery in the lower Columbia River estuary, and that CR chum salmon will be handled and/or killed during those activities. However, these activities are expected to maintain the 30 percent reduction in predation rates achieved under the 2008 RPA (NMFS 2019). These programs are a continuation of existing programs and are not part of the Proposed Action.

Adult CR Chum Salmon Migration Through CRS Dams

One population of CR chum salmon migrates upstream of Bonneville Dam, but most of the chum salmon spawn downstream of Bonneville Dam. Many of the 2008 BiOp actions were directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived high-mortality life stages, such as marine residence and tributary rearing, and are nearly at the point of spawning and giving rise to successive generations. Because this factor potentially affects a small proportion of the chum salmon ESU, additional information related to modeling results for adult survival and abundance is not available.

Adult CR Chum Salmon Migration Upstream of the CRS to the Spawning Areas

Because most of the CR chum salmon ESU spawns downstream of Bonneville Dam in the mainstem Columbia River and a few tributaries, implementation of the Proposed Action will have no effect on upstream migration of CR chum salmon.

Tributary Habitat Actions

For CR chum salmon, habitat degradation is the result of past and present anthropogenic activities. Tributary habitat for CR chum salmon varies significantly throughout the lower Columbia River region. In some areas, habitat is minimally degraded, in other areas it is highly degraded.

As described previously, many factors limit the viability of this ESU. In response to these variability-limiting factors, federal, state, tribal, local, and private entities, including the Action Agencies, have implemented many habitat measures specifically to benefit CR chum salmon.

Based on the best available science, NMFS has concluded that these actions have improved, and will continue to improve, habitat for CR chum salmon. Furthermore, fish population abundance, productivity, spatial structure, and diversity should respond positively to improvements in the baseline habitat conditions (NMFS 2019).

Fish Status and Trend Monitoring

It is anticipated that the Action Agencies' RM&E program will continue at current or somewhat reduced levels of effort. As such, the level of injury and mortality associated primarily with the capture, handling, and marking/tagging of CR chum salmon is expected to be maintained at current or slightly decreased levels.

Implementation of the Proposed Action will not alter fish monitoring programs associated with CR chum salmon, and as such, no effects of these actions are anticipated for this ESU.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

The effects of the Proposed Action on critical habitat are discussed in this section. Effects on critical habitat were assessed based on the elements of the Proposed Action that are likely to affect the PBFs essential for the conservation of the CR chum salmon ESU. Effects on designated critical habitat include the Proposed Action and associated mitigation that affect habitat within the freshwater migration corridor and estuarine areas.

Freshwater Spawning and Rearing Sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of CR chum salmon. Freshwater spawning and rearing areas occur primarily within mainstem sections of the Columbia River downstream of Bonneville Dam, and within some tributaries. For the tributary (and to some degree mainstem) habitat program there will be some uncertainty about the actual locations, extent, and types of habitat actions that will be implemented as part of the Proposed Action. However, the anticipated effects of the habitat improvement program are expected to include potential effects, and these will be mitigated through compliance with the BiOp on Columbia River habitat improvements (NMFS 2013).

Freshwater Migration Corridors

Freshwater migration corridors are used by returning adult CR chum salmon migrating downstream from the CRS and by juvenile CR chum salmon migrating downstream from the spawning grounds in the mainstem Columbia River. The CRS dams and reservoirs have affected and will continue to affect the PBFs within the mainstem Columbia River downstream of Bonneville Dam. Ongoing implementation of the Action Agencies' predator management programs should improve survival by reducing the consumption of juvenile and adult salmon within the CRS, including areas downstream of Bonneville Dam. These programs will continue to reduce the risk of predation on CR chum salmon.

The Proposed Action also includes both structural and operational modifications to the CRS that may affect the PBFs related to water quality and passage conditions through which CR chum salmon must migrate to complete their life cycle. However, the overall effects on these PBFs from implementing the Proposed Action are slightly positive with respect to passage conditions and risk of predation, and slightly negative relative to elevated TDG. Continued effects on stream temperature, sediment, and turbidity PBFs are anticipated with the CRS, but effects on these water quality indicators are likely to remain unchanged as a result of the Proposed Action.

Estuarine and Nearshore Marine Areas

Estuarine and nearshore marine areas have been designated as being essential for the conservation of CR chum salmon. The Columbia River estuary occurs downstream from the CRS so the effects of the Proposed Action are attenuated as distance increases downstream from Bonneville Dam and large tributary streams influence water quality in the Columbia River. Ongoing implementation of the Columbia River estuary habitat and predator removal or harassment programs are anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of the habitat program is likely to increase the capacity and quality of habitat in the Columbia River estuary, while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal or harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to influence the risk of predation on CR chum salmon.

The Proposed Action includes operational modifications to the CRS that may affect water quality downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions with a slight but potential increase in TDG associated with the flex spill program. The highest TDG levels (125 percent) are expected in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). In juvenile salmon, an increase in TDG will likely manifest in an increased incidence GBT. It is anticipated that later migrating adult CR chum salmon will not be affected by the flex spill program because of their migrational timing. Continued effects on stream temperature, sediment, and turbidity are anticipated downstream from the CRS but are likely to remain unchanged as a result of the Proposed Action. Current passage conditions will be unaffected for juvenile and adult CR chum salmon as they migrate through the Columbia River estuary.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on CR chum salmon in the context of existing conditions and cumulative effects. Cumulative effects are effects of future state or private activities that are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline condition (whether they are federal, state, or private). To the extent those same activities are reasonably certain to occur in the future (and are state or private), their future effects are included in the cumulative effects analysis.

Most of the action, baseline, and cumulative effects identified in the analysis above are consistent with effects previously described for operation of the CRS in past consultations. In general, the Proposed Action does not result in substantial changes in the identified effects, but there may some modest site-specific effects.

The summary below follows the general structure of the analysis above and discusses each factor that was previously evaluated.

Operational

Survival

Survival of juvenile CR chum salmon through the CRS is affected by dam passage, predators, travel time, and water quality. These factors are the result of multiple factors, including the existence and past operation of the CRS. Survival rates have improved for salmon and steelhead migrating through the CRS to the ocean as a result of past changes in operations and improvements in baseline conditions. Juvenile CR chum salmon survival has also improved in the estuary and tributaries because of habitat improvements implemented by the Action Agencies. For adult CR chum salmon, survival is affected in the estuary up to Bonneville Dam by pinniped predators.

Cumulative future non-federal actions, and the effects of climate change and variable ocean conditions, have the potential to affect survival of CR fall chum salmon. Land use activities (primarily non-federal) have the potential to affect juvenile survival by decreasing tributary and estuary habitat or degrading abiotic factors, such as stream temperatures from urban, rural, and agricultural development and runoff. Further degradation of tributary habitat could also affect adult CR Chum salmon survival by reducing holding and spawning areas, or developing passage barriers. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies implement fisheries that can have a direct effect on the number of returning salmon.

It is anticipated that survival gains resulting from previous actions that improved baseline conditions will continue and possibly increase as a result of continuing tributary and estuary habitat actions. It is also anticipated that improvements in juvenile and adult passage conditions at the CRS dams will be maintained. For downstream migrating juveniles, it is anticipated that not only will survival through the CRS improve, but ocean survival may increase as a result of fish entering the ocean with reduced powerhouse passage during their downstream migration, if the latent mortality hypothesis proves to be valid. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and will inform potential modifications of actions.

Travel Time

The existence of the CRS has increased juvenile travel time compared to the pre-CRS condition, potentially increasing exposure to predators as the juveniles migrate through the CRS. Travel time within the tributaries and estuary are not affected by the existence or operation of the CRS. While travel time of juveniles within the CRS varies from year to year, the Proposed Action continues past actions that send more fish through non-turbine routes, which is believed to decrease travel time and improve survival. Adult travel time is not considered an issue.

Future state and private actions are not expected to affect the travel time of juveniles or adults through the CRS during any life stage. However, it is anticipated that climate change will continue to increase overall temperatures in the Columbia River, and therefore have the potential to further affect adult CR chum salmon upstream migrational timing, and possibly juvenile emigration timing.

The Proposed Action is anticipated to reduce forebay residence time (a decrease in downstream travel time) for juvenile CR chum salmon migrating past Bonneville Dam during the flexible spill plan

implementation. Continued monitoring of adult CR chum salmon migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse passage proportion

Past and current physical and operational modifications of the CRS have increased the percentage of juvenile fish passing via non-turbine routes. Decreasing powerhouse passage improves survival of juveniles during their downstream migration and provides a safer route of passage for adult migrants that overshoot their natal stream.

The effects of state and private actions are not anticipated to affect juvenile CR chum salmon powerhouse passage.

The Proposed Action will continue implementing past improvements and actions that have resulted in increased non-turbine passage at the CRS projects.

Water quality

TDG

TDG has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high levels that resulted in GBT in juveniles and adults as they migrated through the CRS. Elevated TDG levels are not observed within tributaries or the estuary (where the effects of CRS operations on TDG are attenuated by distance and tributary inflow). The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

The only state or private actions that will affect TDG levels in the mainstem Columbia River are modifications to state water quality criteria and operation of non-federal hydroelectric facilities. Continued monitoring of juveniles and adults for signs of GBT will inform managers about the effects of this action.

It is anticipated that implementing the flexible spill program will elevate TDG levels and may slightly increase the incidence of GBT in juvenile fish. However, due to the run timing of adult LC chum, no increase in GBT during this life stage is anticipated.

Temperature changes

Water temperatures have been modified as a result of a range of anthropogenic activities, including the existence and on-going operation of the CRS, throughout the Columbia River Basin. Increases in temperature can have a range of effects on both juvenile and adult CR chum salmon.

Ongoing non-federal land management activities that affect temperature, such as agriculture and urban and rural development, and forestry, are not expected to change substantially during the period of this consultation. These activities, coupled with continued population growth in the region, will likely result in further degradations of the environment that influence water temperatures. However, small

improvements may be realized from tributary actions that restore and preserve habitat, like riparian plantings.

Implementation of the habitat enhancement action component of the Proposed Action will improve tributary temperatures but will continue to have minimal effect on mainstem temperatures.

Turbidity levels

Currently, sediment loads in tributaries have been affected by historic land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade spawning and rearing habitat. In the mainstem Columbia and Snake Rivers, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk. These baseline conditions will persist during the period of the Proposed Action.

In the tributaries of the Columbia and Snake Rivers, non-federal actions such as urban, rural, and agricultural development are likely to continue to affect turbidity, but improvements in tributary habitat included in the Proposed Action are expected to result in reduced sediment inputs, resulting in modest, site-specific improvements that will mitigate continued non-CRS activities that degrade habitat. In the CRS, the current condition is not anticipated to change, and no non-federal activities are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment delivery levels from the tributaries. On the mainstem Columbia River, it is not anticipated that the Proposed Action will change the current condition.

Dam passage (adults)

Most CR chum salmon production occurs downstream of Bonneville Dam although some salmon migrate upstream of Bonneville Dam on their way to natal spawning areas and experience a variety of factors affecting them, including incidental harvest,²⁸ dam passage, straying, pinniped predation, and temperature and flow conditions that can increase the energy demands of migrating fish. Current adult passage conditions should improve with modifications at Bonneville Dam fishways, which should improve passage.

Non-federal actions that have the potential to directly affect CR chum salmon adults migrating through the CRS are unlikely. However, the continued degradation of tributary habitat that increases temperatures, and climate change that results in warming surface water temperatures indirectly influence migratory behavior in ways that slow or delay upstream migration and reduce survival and reproduction.

The Proposed Action will continue to monitor adult migration through the CRS and use that information to propose specific actions that will increase adult survival.

²⁸ There is no directed harvest of CR chum salmon. Commercial harvesters in the Lower Columbia River have taken fewer than 100 fish per year since 1993, and all recreational fisheries have been closed since 1995. The overall exploitation rate has been less than 1 percent in recent years (NMFS 2019).

Predation

Currently, both juvenile and adult CR chum salmon encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinniped predators prey on adults as they enter the Columbia River from the ocean to the tailrace of Bonneville Dam. A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS and estuary.

Non-federal actions are not anticipated to affect predation rates. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them is removed from the CRS.

The Proposed Action will continue to implement the predator management programs, which should ensure that predation does not worsen, and may reduce overall predation rates over time. Some impacts on CR chum salmon will occur as a result of implementing the northern pikeminnow predation program, but those impacts are considered minor.

Non-operational

Hatcheries

The Columbia River Basin currently has more than 170 hatchery programs and there are currently 2 hatchery programs for CR chum salmon that are paid for by the Action Agencies. The primary purpose of these hatcheries is to mitigate for either lost habitat or loss of production due to operation of hydro facilities, including the CRS. The extent of effects (adverse or beneficial) of hatchery programs on natural-origin CR chum salmon and their habitat depends on the design of hatchery programs, the condition of the habitat, and the status of the species, among other factors.

It is anticipated that the two current hatchery programs will continue into the future, and the potential effects of hatchery fish on natural-origin fish will continue. Current hatchery programs will continue to be studied and management agencies will recommend how to reduce potential effects if they occur.

Habitat actions

Currently, habitat conditions in the tributaries, mainstem Columbia River, and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect CR chum salmon include continued degradation of estuary habitat and climate change that is warming surface water temperatures.

The Proposed Action will continue to rehabilitate habitat in the mainstem Columbia River and estuary.

Fish status and trend monitoring

There are potential effects from CRS-related RM&E programs on CR chum salmon. These are associated with the capturing and handling of fish. RM&E activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no non-federal actions anticipated that would affect RM&E activities.

The Proposed Action will continue to implement the RM&E programs that are currently occurring, and may modify these programs in the future as the results of the monitoring programs are evaluated.

Summary

The effects of the Proposed Action are summarized in Table 3-62, where the effects of the Proposed Action are compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action. Most of the actions are anticipated to either have no effect, or a positive effect compared to the current condition (Table 3-62). Positive effects are anticipated in freshwater rearing and spawning areas due to improvements associated with tributary habitat improvement programs, and within the CRS as a result of the flex spill program, which improves survival as a result of increased spill, decreased powerhouse encounters, and reduced juvenile travel time. Conversely, the increased spill levels also account for negative impacts due to increased levels of TDG, and potentially GBT in both juveniles and adults. Both juveniles and adults experience benefits from predator control programs; for juveniles mainly up and downstream from CRS projects, and for adults in the estuary and downstream from Bonneville Dam.

Table 3-62. Summary comparison of the Proposed Action to current conditions for LCR chum salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Chinook Down-stream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x		+	Continuation of predator management programs should decrease predation.
	Hatcheries	x		=	
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Juvenile Chinook Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
Fish status and trend monitoring	x		=		
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Chinook Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
	Predation monitoring		x	=	
Fish status and trend monitoring		x	=		

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Adult Chinook Migration Through CRS Dams	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)		x	+	Monitoring adult migration may assist in development of actions to reduce fallback.
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring		x	=	
	Fish status and trend monitoring		x	=	
Adult Chinook Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	+	Existing and future habitat improvements will likely improve tributary water temperatures
	Turbidity levels		x	+	Existing and future habitat improvements will likely improve tributary turbidity levels
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Fish status and trend monitoring		x	=	

3.1.6 Willamette Salmonid Species

3.1.6.1 Upper Willamette River Chinook Salmon

STATUS OF UPPER WILLAMETTE RIVER CHINOOK SALMON ESU

This section details the status of the upper Willamette River (UWR) Chinook salmon and the effects of the Proposed Action on the species. The analysis shows that most of the life cycle of UWR Chinook salmon and its critical habitat are not exposed to the Proposed Action. During part of the migration, all individuals of this ESU are exposed to the Proposed Action in the lower Columbia River, where there are no CRS facilities. The Action Agencies' proposal to continue to operate and maintain the CRS and associated mitigation is expected to affect individuals of this ESU in minor, adverse, and beneficial ways. It is not likely that the Proposed Action would cause reductions in overall species reproduction, numbers, or distribution to the degree of reducing appreciably the species' likelihood of survival and recovery in the wild. CRS operations are expected to affect a small proportion of the critical habitat (101 of 1,472 miles) for this ESU and, compared to current conditions, do not diminish the value of critical habitat in the action area.

The UWR Chinook salmon (*O. tshawytscha*) ESU is composed of 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 five artificial propagation programs (Figure 3-26). Seven historical, demographically independent populations have been identified, but significant natural production now occurs only in the Clackamas and McKenzie River subbasins. The other naturally spawning populations are small and mostly composed of hatchery-origin fish. NMFS expresses the status of an ESU in terms of the status and extinction risk of its individual populations, relying on McElhany et al.'s (2000) description of a viable salmonid population. The 2011 Conservation and Recovery Plan for UWR Chinook salmon and steelhead (ODFW and 76 FR 65324) describes the viability criteria in detail and the parameter values needed for persistence of individual populations and for recovery of the ESU. Although the risk categories for the seven populations range from low to very high, the extinction risk for the ESU overall is high to very high.

UWR Chinook salmon were listed as threatened on March 24, 1999. That status was affirmed in 2005 and updated on April 14, 2014. The recovery plan was completed in 2011 (ODFW and 76 FR 65324), and the last 5-year status review was completed in 2016 (NMFS 2016d). We incorporate by reference the NMFS description of the range-wide status of the species NMFS (2019), p 55-60. Best available information indicates that the UWR Chinook salmon ESU remains at threatened status (Table 3-63).

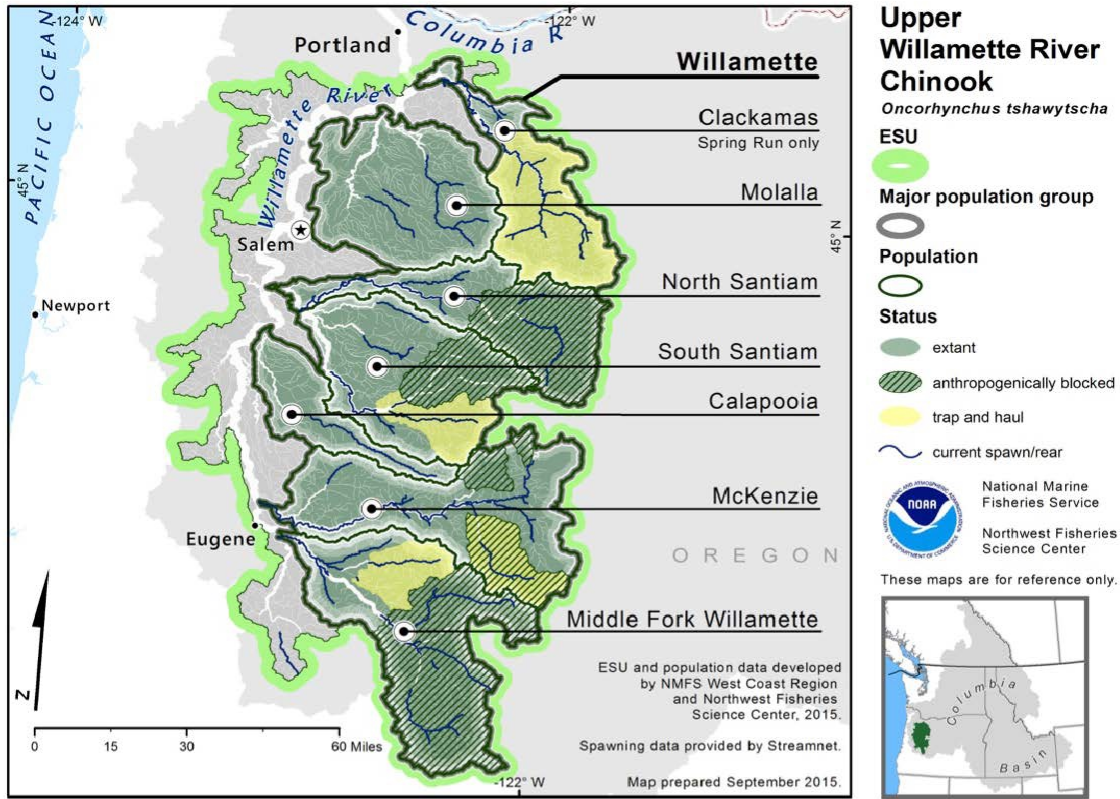


Figure 3-26. Map of the Upper Willamette River Chinook salmon ESU’s spawning and rearing areas, illustrating populations and major population groups [source: (NWFSC (Northwest Fisheries Science Center) 2015)]

Table 3-63. Scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall viability risk for UWR Chinook salmon

Population (Watershed)	A/P	Diversity	Spatial Structure	Overall Extinction Risk
Clackamas River	M	M	L	M
Molalla River	VH	H	H	VH
North Santiam River	VH	H	H	VH
South Santiam River	VH	M	M	VH
Calapooia River	VH	H	VH	VH
McKenzie River	VL	M	M	L
Middle Fork Willamette River	VH	H	H	VH

VL = Very Low; L = Low; M = Moderate; H = High; VH = Very High

Sources: [ODFW and NMFS (2011) and NWFSC (Northwest Fisheries Science Center) (2015)]

FACTORS AFFECTING THE STATUS OF UWR CHINOOK SALMON (BY LIFE STAGE)

Many human activities and natural processes continue to affect UWR Chinook salmon throughout their life cycle. This ESU spends most of its life cycle (2 to 6 years) rearing in Willamette River Basin freshwater and ocean habitats. To help interpret the information presented under the Effects of the Action section, and thus inform the Section 7(a)(2) analysis, the following section discusses past and current factors affecting various life stages of this ESU related to the Proposed Action. Information presented under each life-stage heading below indicates how multiple human activities, combined with variable natural conditions, have degraded conditions for this ESU over time. NMFS (2019) (p. 62-74) described factors that negatively and positively affected the abundance, productivity, diversity, and spatial structure of UWR Chinook salmon populations. Below, we clarify some aspects and supplement that description of the environmental baseline.

In 1999, when UWR spring Chinook and winter steelhead were listed under the ESA (64 FR 14307), NMFS cited all of the five listing factors as contributing to the decline of these species. Specifically, the major concerns described were related to (1) loss of historic spawning and rearing habitat due to dam blockages in the eastside tributaries of the Willamette River, (2) adverse thermal effects downstream from operation of the dams (in the Willamette Valley), (3) riparian and stream habitat loss and degradation, particularly in the lowland, valley areas, (4) excessive fishery harvest, and (5) adverse effects from hatchery programs (ODFW and NMFS 2011).

The Willamette Valley was not glaciated during the last epoch (McPhail and Lindsey 1970), and Willamette Falls likely served as a physical barrier for reproductive isolation of Chinook salmon populations. This isolation had the potential to produce local adaptation relative to other Columbia River populations (Myers et al. 2006). Fish ladders were constructed at the falls in 1872 and again in 1971, but it is not clear what role they may have played up to the present day in reducing localized adaptations in UWR fish populations. Little information exists about the life-history characteristics of the historical UWR Chinook salmon populations, especially because early fishery exploitation (starting in the mid-1880s), habitat degradation in the lower Willamette Valley (starting in the early 1800s), and pollution in the lower Willamette River (by early 1900s) likely altered life-history diversity before data collections began in the mid-1900s.

Combined past human activities in the Willamette River Basin, Columbia River Basin, and ocean habitats led to the decline of the UWR Chinook salmon. All losses of anadromous fish before they reach their spawning and rearing areas reduced the transport of marine-derived nutrients, which are important for salmonid production and consequently for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2002). Gresh et al. (2000) estimated that the marine-derived nitrogen and phosphorus load delivered to Pacific Northwest rivers has decreased more than 90 percent in the last 140 years. Their study attributed the loss of marine-derived nutrients to habitat changes due to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing.

Freshwater spawning and rearing and migration to the Columbia River

UWR Chinook salmon spawn, rear, and migrate in the Willamette River Basin. The Willamette River Basin covers 11,500 square miles and encompasses parts of three physiographic provinces. The Cascade Range covers 60 percent of the basin and consists of volcanic rocks with elevations exceeding 10,000

feet. The Willamette River Valley is home to 70 percent of Oregon’s human population (NPCC 2004a), including Oregon’s three largest cities (Portland, Eugene, and Salem). Approximately 70 percent of the basin is forested, and approximately 36 percent of the basin is under federal forest ownership. Most of the federal forest land is located in the higher elevations of the Cascade and Coast Ranges and is managed by the United States (U.S.) Forest Service and U.S. Bureau of Land Management. About 22 percent of the basin area is in agricultural production, and the remaining 8 percent is urbanized or in other uses (Wentz et al. 1998). More than 60 percent of the basin area is outside the urban growth boundaries, and more than 90 percent of the valley floor is privately owned (PNERC 2002). Several major flood control or hydropower facilities have been developed in the Clackamas River subbasin and in subbasins of the upper Willamette River Basin, including facilities in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette Rivers. The existence and operation of dams affect salmonids by hindering fish passage to the most productive and important upstream spawning and rearing habitat, and by altering the natural hydrologic regimes, especially during summer and fall low-flow periods. Anadromous fish habitat in the Willamette River Basin has been strongly affected by flood control, hydropower management, and land use.

Access to historical spawning and rearing areas is restricted by large dams in the four historically most productive tributaries (North Santiam, South Santiam, Middle Fork Willamette, and McKenzie Rivers) and is a key limiting factor to recovery. In the absence of effective passage programs, the fish will continue to be confined to more lowland reaches where land development, water temperatures, and water quality are limiting. Pre-spawning mortality levels are generally high in the lower tributary reaches, where water temperatures and fish densities are generally the highest (NMFS 2016d).

According to NMFS, current limiting factors for this ESU during this life stage include the following:

- climate change effects, including projected increased stream temperatures and projected changes in precipitation and streamflow
- restricted access to historical and more productive spawning and rearing habitats in the four historically most productive tributaries—the North Santiam, South Santiam, Middle Fork Willamette, and McKenzie Rivers
- poor habitat quality and high pre-spawning mortality in the accessible, lowland reaches where land development, water temperatures, and water quality are limiting
- anthropogenic introductions of non-native species and out-of-ESU races of salmon or steelhead have increased predation on, and competition with, native UWR Chinook salmon
- poor downstream juvenile passage from the historically high-quality habitat above Cougar Dam (South Fork McKenzie River)
- degraded and lost juvenile rearing habitat, including floodplain connections, velocity refuges, and shallow-water habitat, especially from levees and bank-armoring projects and increased development (especially in areas like Portland Harbor)
- human population growth effects, including increased water use, land use, development, and pollution levels

- higher pinniped predation rates on adults at Willamette Falls and continued non-native fish predation on fry and smolts in the Willamette River
- a high, but declining, proportion of hatchery-origin fish on spawning grounds.

Past and present effects of CRS dams and past operations

UWR spring Chinook salmon spawn and rear in the Willamette River Basin, where there are no CRS facilities or operations that affected this ESU in these life stages or as they migrated to the Columbia River.

Past and present effects of hatcheries

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 2017b). NMFS directs federal funding to many of the hatchery programs in the lower Columbia River through the Mitchell Act. NMFS completed a BiOp on its funding of the Mitchell Act program in 2017 (NMFS 2017b). As a result of this consultation, several reform measures will be 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. A reduction in the number of hatchery fish released over the last 10 years will likely reduce the effects of hatcheries on UWR natural-origin Chinook salmon in the lower Columbia River (NMFS 2017b).

Juvenile salmon downstream migration and estuary rearing from the Columbia River at the confluence of the Willamette to the plume

UWR Chinook salmon spend most of their life in the Willamette River Basin or the ocean. They migrate as juveniles and adults from the Willamette River confluence with the Columbia River to the ocean during these life stages. The Columbia River Basin has more than 450 dams, which are managed for hydropower, flood control, and other uses. Together, these dams provide active storage of 42 million acre-feet of water; the dams in Canada account for about half of the total storage [Northwest Power and Conservation Council (2001) as cited in NMFS (2011a)]. Water storage projects on the mainstem Columbia River (dams and reservoirs) and water management activities from all sources have reduced flows between Bonneville Dam and the mouth of the Columbia River compared to unregulated flows in the late spring and summer months; on average, this reduction can range from nearly 15,000 cfs in August to more than 230,000 cfs in May. The combined effects of water uses throughout the basin may have affected water temperatures in the lower Columbia River below the CRS dams at times, but such effects are also influenced by climate, runoff conditions, and the temperatures of tributaries like the Willamette River that enter the Columbia River in the lower basin.

Dams and reservoirs have also 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; Simenstad et al. 1990; National Research Council 1996). Similarly, Bottom et al. (2005) estimated that

the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington). This reduction has altered the development of habitat along the margins of the river. Multiple limiting factors still affect this ESU.

The estuary provides important migratory and rearing habitat for UWR Chinook populations. Since the late 1800s, 68 to 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 (Kukulka and Jay 2003; Bottom et al. 2005). 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 (ERTG 2019).

The most extensive urban development in the lower Willamette River subbasin has occurred in the Portland/Vancouver area. Common water-quality issues in areas that have urban development and rural residential septic systems include higher water temperatures, reduced dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005). These legacy habitat contaminants are a limiting factor for Chinook salmon recovery in the Willamette River Basin (Lundin et al. 2019).

Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the lower Willamette River for navigation channels. 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 navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, also 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, and temperature refugia; (Bottom et al. 2005)]. The upland placement of dredged material can affect piscivorous bird populations in the lower Columbia River. Dredging activities are addressed in a separate Section 7 (a)(2) consultation and are not part of this CRS operations consultation.

The majority of UWR spring Chinook salmon juveniles migrate as yearlings from March through May (CRSO in prep); however, other migrations occur throughout the year. The current limiting factors for this ESU during this life stage include the following:

- an altered seasonal flow regime and Columbia River plume due to water diversions and water management projects
- degraded and lost juvenile rearing habitat, including floodplain connections, velocity refuges, and shallow-water habitat, especially from levees and bank-armoring projects and increased development (especially in areas like Portland Harbor)
- reduced productivity resulting from sediment and nutrient-related changes in the estuary
- human population growth effects, including increased water use, land use, development, and pollution levels

- continued avian predation on smolts in the Columbia River estuary
- continued non-native fish predation on fry and smolts in the Columbia River.

Although many of these factors occur outside of the mainstem Columbia River and estuary migration corridor, they affect the abundance and fitness of juveniles, which affects their abundance and survival at subsequent life stages.

Past and present effects of CRS dams and past operations

There are no dams in the Columbia River from the confluence of the Willamette River to the ocean where UWR Chinook salmon migrate. CRS flow management operations at large CRS storage reservoirs in the interior of the Columbia River Basin can affect habitat in the lower Columbia River mainstem and estuary, and, potentially, the Columbia River plume. The existence of the 14 CRS dams and past operations for all purposes contributed to decreased flows in the lower Columbia River during the spring migration of this ESU and increased flows during migrations from October to March. Reduced flows may have increased travel times during outmigration for juvenile salmonids and reduced access to high-quality estuarine habitats during spring through early summer. To the extent that existence of the CRS affects water temperature in the lower Columbia River, the effects in the estuary are estimated to slightly reduce maximum summer water temperature, decrease water temperature variability, and cause water temperatures to stay cooler longer into the spring and warmer later into the fall compared to an unregulated river. Such changes would be attenuated with distance from the reservoirs and commingled with tributary flows, climatic events, runoff shape and size, and other human activities not related to CRS operations.

The existence of the dams decreased sediment downstream of Bonneville Dam, which, at times, could affect predation rates on this ESU during juvenile migration by making the fish easier to see.

CRS flow augmentation and water quality management

Columbia River flows are primarily driven by snowmelt, and more than 60 percent of the annual runoff occurs between April and June. Natural flows drop significantly by late July and into August. To enhance fish flows, Bonneville and the Corps negotiated an agreement with Canada through the Columbia River Treaty that allowed use of 1 million acre-feet of water in Columbia River Treaty storage space for release during the spring and summer to support flows for fish downstream in the United States. In addition, Bonneville and BC Hydro negotiated a Non-Treaty Storage agreement that includes a provision to provide an additional 0.5 million acre-feet of flows during the spring in the driest 20th percentile of years, if not exercised in the previous year. Further, the Treaty provides for drafting of reservoirs in drier years [Corps et al. (2017a), Section 1, pp. 13, 14]. NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. These flow objectives have guided pre-season reservoir planning and in-season flow management (NMFS 2019).

The Water Quality Plan includes actions to help manage The DG supersaturation that can occur from upstream dam spill operations. Elevated TDG can occur for 35 miles below Bonneville Dam. UWR Chinook juvenile migrants are not likely exposed to this elevated TDG because the Willamette River is 46

miles downstream from Bonneville Dam; however, the few adult salmon that swim upstream of the Willamette River could be exposed at times.

Estuary Habitat Program

The Action Agencies have implemented many estuary habitat improvement actions. Because juvenile 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), improved connectivity of floodplain habitat for feeding and growth likely contributes to survival when smolts first enter the ocean. Although yearlings do not use the low-velocity, shallow-water habitats to the same extent as subyearlings, improved opportunities for feeding likely improve survival to the early ocean life stage, as well. Restoration actions in the estuary, such as those highlighted in the NMFS (2016e) 5-year review, have improved access and connectivity to habitat in the estuary.

Predator management

Past CRS operations do not define the number of bird, fish, and pinniped predators of salmon in the lower Columbia River. However, the Action Agencies implemented predator management activities to help protect the federal investment in salmon recovery. The Action Agencies have created Caspian tern nesting habitat outside of the Columbia River Basin to allow reduction in the amount of nesting habitat on East Sand Island, decreasing the number of birds there and thereby decreasing predation on salmon smolts in the estuary [Corps et al. (2017a) p. 35]. During the period from 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 (NMFS 2019; p. 69). The Corps also implemented a double-crested cormorant management plan in the estuary. Based on PIT tag recoveries at East Sand Island, average annual tern and cormorant predation rates for UWR Chinook salmon were about 2.5 and 1.3 percent, respectively, before efforts to manage these colonies (Evans et al. 2018). Predation rates on UWR Chinook salmon for East Sand Island terns have since decreased to 1.0 percent, but in 2017, this improvement was offset to an unknown degree by terns roosting farther upstream on Rice Island (Evans et al. 2018).

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River Basin, including the estuary, followed by non-native smallmouth bass and walleye (ISAB 2011, 2015). Since 1990, Bonneville has funded the NPMP to reduce the numbers of larger pikeminnow and improve survival of juvenile salmon. The NPMP relies on private-sector fishing efforts, through the Northern Pikeminnow Sport Reward Fishery, to provide the majority of the catch of northern pikeminnow. 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 purpose of this program is to protect salmon smolts; however, the fishing effort sometimes incidentally catches salmon and therefore could adversely affect a small number of UWR Chinook salmon.

Ocean rearing

Once they enter the Pacific Ocean, UWR Chinook migrate north along the coasts of British Columbia and southeastern Alaska (Myers et al. 2006). The majority of both hatchery-origin and natural-origin UWR Chinook adults are 4 and 5 years old when they return to freshwater, with small proportions of age-3 and age-6 fish. Thus, these fish rear 1 to 4 years in the ocean. Recent observations of coastal ocean conditions suggest that the 2015–2017 outmigrant year classes experienced below-average ocean survival, which predicts a corresponding drop in adult returns through 2019 (Werner et al. 2017).

Past and present effects of harvest

Ocean harvest rates of approximately 30 percent and fishery-related mortalities are listed in the recovery plan as limiting factors. UWR Chinook salmon are taken in ocean fisheries, primarily in Canada and Alaska. Ocean fishery impacts on UWR spring Chinook salmon are typically in the range of 10 to 15 percent under current agreements in the Pacific Salmon Treaty. The anticipated harvest rate on UWR spring Chinook salmon in the proposed mainstem Columbia River fisheries in 2018 through 2027 ranges from 5 to 11 percent and will not exceed an overall harvest rate of 15 percent from all freshwater fisheries combined. The 2018 Agreement proposes to continue adhering to these limits for harvest effects on UWR Chinook salmon (2018). Harvest rates in ocean fisheries have averaged 9.5 percent since 2009 (PSC-CTC 2018), and NMFS found that there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status; distribution of the populations is not restricted or modified in a measurable way that would alter their ability to recover.

Past and present effects of CRS dams and past operations

There are no CRS facilities in the ocean, and CRS past operations have had no effect on this ESU during the 2- to 3-year ocean life stage.

Migration of adult upper Willamette River Chinook salmon through the lower Columbia River to the Willamette River

As discussed in the juvenile migration section, multiple human activities have affected the ecosystem of the lower Columbia River and therefore likely have affected the migration of adult UWR Chinook salmon as they returned to the Willamette River.

Past and present effects of harvest

UWR Chinook salmon have been harvested in lower mainstem Columbia River commercial gillnet fisheries and in recreational fisheries in the mainstem Columbia River and the Willamette River. These fisheries are directed at hatchery production but historically could not discriminate between natural-origin and hatchery fish. Harvest rates in freshwater fisheries have averaged 9.5 percent since 2008 (TAC 2017); *U.S. v. Oregon* (2018). Hooking mortalities are generally estimated at 10 percent, although river temperatures likely influence this rate. Illegal harvesting of unmarked fish is thought to be low (NWFSC (Northwest Fisheries Science Center) 2015).

Past and present effects of CRS dams and past operations

There are no CRS dams that impede migration in the lower Columbia River as these fish migrate to the Willamette River. Adult UWR Chinook salmon enter the Willamette River from January to April each year, and they enter the Columbia River prior to this. Flow and TDG effects on the lower Columbia River related to CRS operations during this period usually do not adversely affect the adult migration because flows are slightly higher than would occur under unregulated conditions, little TDG is generated during this period, and water temperatures are adequate for migration.

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 PBFs of that habitat throughout the designated area. 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/or foraging). Table 3-64 summarizes status information for designated critical habitat for UWR Chinook salmon based on the detailed information on the status of critical habitat provided in the recovery plan for the species and the recent status review (ODFW and NMFS 2011)(NMFS 2016d). UWR Chinook salmon critical habitat is within the Willamette/lower Columbia River recovery domain.

Anthropogenic effects on designated critical habitat in the Willamette River Basin, particularly the major water storage and hydroelectric projects, have significantly reduced access to spawning habitat in the four most historically productive basins. Other factors affecting the condition of designated critical habitat for UWR Chinook salmon and the essential PBFs include the following:

- Increases in water use and storage
- Destructive land use activities
- Urban development and other effects related to human population growth (primarily in the Willamette River Basin, but also in the Columbia River Basin and estuary)
- Degraded freshwater habitat, especially floodplain connectivity and function, channel structure and complexity, and riparian areas and large wood recruitment as a result of cumulative impacts of agriculture, forestry, and development
- Degraded water quality and altered water temperatures as a result of both tributary dams and the cumulative impacts of agriculture, forestry, and urban development.

All of these factors have reduced the quality of many remaining habitat areas by weakening important watershed processes and the functions that sustained them. The critical habitat status summary (70 FR 52630 2005) for UWR Chinook salmon stated that:

Critical habitat encompasses 10 subbasins in Oregon containing 60 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with essential PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some, or high, potential for improvement. Of these 60, 19 watersheds received a low rating, 18

received a medium rating, and 23 received a high rating of conservation value to the ESU. The lower Willamette/Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high-value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. 1,472 miles of stream are designated critical habitat for the Upper Willamette Chinook Salmon ESU.

The PBFs for UWR Chinook salmon critical habitat are summarized here in Table 3-64. Restoration activities addressing access to the historical estuarine floodplain are improving the baseline condition for that PBF.

Table 3-64. PBFs of designated critical habitat within the action area for UWR Chinook salmon

PBF	Components of the PBFs	Principal Factors Affecting Condition of the PBFs
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	Freshwater rearing sites (except in the estuary; see below) are not affected by the action
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting)
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
Nearshore marine areas ¹	Free of obstruction and excessive predation with water quality, quantity, and forage	Concerns about increased opportunities for pinniped predators, adequate forage

¹ Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

PROPOSED ACTION COMPONENTS SPECIFIC TO UWR CHINOOK SALMON

Some parts of the Proposed Action are designed to benefit the lower Columbia River and therefore would benefit UWR Chinook salmon. These actions include flow augmentation, actions to reduce TDG below Bonneville Dam, the estuary habitat program, and avian and fish predator management in the estuary.

EFFECTS OF THE ACTION ON UPPER WILLAMETTE RIVER CHINOOK SALMON

The Action Agencies propose to continue operating the CRS in accordance with the applicable Water Management, Fish Passage, and Water Quality plans, including associated appendices. This analysis assumes proposals to continue predator management activities, to continue the estuary habitat program, and to continue various research and monitoring activities in the lower Columbia River. This analysis focuses on life stages in which UWR Chinook salmon are present in the Columbia River and estuary during downstream juvenile salmon migration, estuary rearing, and adult migration upstream through the lower Columbia River to the Willamette River. The operation and maintenance of the CRS have no effect on this ESU for the life stages of freshwater spawning and rearing, juvenile migration to the Columbia River, and ocean rearing. The operation and maintenance of the CRS may subject a minimal number of adults that stray past the Willamette River to elevated TDG levels upstream near Bonneville Dam.

Juvenile salmon downstream migration (and estuary rearing) from the Columbia River at the confluence of the Willamette River to the plume

Juvenile UWR Chinook salmon from all populations will be exposed to the effects of the continuing Proposed Action in the mainstem Columbia River from the Willamette River confluence and through parts of the plume. Juvenile UWR Chinook can migrate as subyearlings or yearlings and in the fall and spring; most of the fish migrate in the lower Columbia River during the spring (ODFW and NMFS 2011, p. 2-5, 2-6). The yearlings move through the estuary fairly quickly, but subyearlings can spend weeks rearing in the estuary (NMFS 2019; p. 78).

Exposure to the Proposed Action is related to the following components of the action:

- CRS-related flood control, water management, and water quality effects from upstream operations (Bonneville Dam, the downstream-most dam, is 45 miles upstream from the Willamette River confluence)
- parts of the Proposed Action that are specifically crafted to improve conditions for salmon including flow augmentation, TDG management, avian and fish predator management, and the estuary habitat actions.

Operational

There are no migration barriers related to CRS operations in the lower Columbia River. Of the 13 limiting factors listed by NMFS in the 2016 status review (NMFS 2016d), only 1 is related, in part, to CRS operations—an altered seasonal flow regime and Columbia River plume due to water diversions and water management projects. The part of the flow regime in the lower Columbia River associated with CRS operations would be similar when comparing 2016 CRS operations and recent baseline conditions. Any elevated TDG related to CRS operations would not extend to the Willamette River and therefore would have no effect on these fish at this life stage. Water temperatures related to continuing 2016 CRS operations upstream would not be different from recent baseline conditions and would be attenuated by the distance from the CRS facilities and commingled with many other factors. Therefore, no effects on UWR Chinook juvenile migration or rearing in the lower Columbia River are expected when

comparing anticipated water temperatures resulting from 2016 CRS operations and recent baseline operations.

Non-Operational

Predator management and monitoring actions

The Action Agencies propose to continue implementation of the Caspian Tern Nesting Habitat Management Plan (Corps 2015a) and the Double-crested Cormorant Management Plan (Corps 2015b). Tern habitat on East Sand Island will be maintained at no more than 1 acre for the period covered by this consultation. Management actions for cormorants will be limited to passive dissuasion and hazing, although limited egg take (up to 500 eggs) may be requested from USFWS in an annual depredation permit application to preclude cormorants from nesting in new or different areas on East Sand Island. These actions have the potential to improve the viability of the UWR Chinook salmon populations by increasing the survival of outmigrating juveniles as they move through the estuary. However, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years and observations of thousands of Caspian terns roosting on Rice Island indicate that the numbers of avian predators in the estuary and their effects on salmonids, such as UWR Chinook salmon, are in flux. We expect insignificant effects on UWR Chinook juvenile migration or rearing in the lower Columbia River when comparing 2016 CRS operations and recent baseline operations.

The NPMP includes the Sport Reward Fishery and Dam Angling programs, which the Action Agencies propose to continue as part of the action. The first is implemented in the lower Columbia River, including the estuary. This fishery removes approximately 10 to 20 percent of predatory-sized pikeminnow per year and is open from May through September, when juveniles can be rearing in mainstem habitats. We expect that the Sport Reward Fishery will continue to improve the survival of juvenile UWR Chinook salmon that are rearing in and migrating through the lower Columbia River; however, comparing 2016 CRS operations to the recent baseline conditions results in little difference.

Habitat Actions

The Action Agencies propose to continue to implement the CEERP to increase the capacity and quality of estuarine ecosystems and improve access for juvenile salmonids. The Action Agencies will continue to emphasize reconnection of floodplain areas in tidally influenced waters of the lower Columbia River and estuary, primarily by modifying levees. Additional actions at habitat improvement sites will include re-creating historical channel networks, reducing the presence of non-native species, and revegetating habitat improvement sites with native vegetation to ensure each site's resiliency. These projects are expected to provide direct and indirect benefits (i.e., increased food availability) to UWR Chinook salmon as they migrate through and rear in the estuary. The subyearling life-history type spends longer times in the estuary (several weeks to months) and, therefore, is more likely to benefit from additional growth in the estuary compared to yearling migrants. We expect minor improvements in habitat that support UWR Chinook juvenile migration and/or rearing in the lower Columbia River when comparing 2016 CRS operations and recent baseline operations, because the action is similar to actions taken in the past.

Research and monitoring activities

The Action Agencies' RM&E program will be similar to the current program or will be implemented at a reduced scale. Based on past reporting, we estimate that, on average, the following numbers of UWR Chinook salmon will be affected each year during the interim period:

- No UWR Chinook salmon will be handled or killed during activities associated with the SMP (Smolt Monitoring Program) and the CSS (Comparative Survival Study).
- Projected estimates of UWR Chinook salmon handling and mortality for all other RM&E programs include: 29,910 hatchery and 14,213 wild juveniles handled, and 299 hatchery and 142 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural-origin) juvenile production for the UWR Chinook salmon ESU (Bellerud 2018). NMFS estimates that 1.11 percent of the wild juvenile production will be handled each year, on average; we expect that only up to 1 percent of these will die after release (i.e., 0.02 percent of adults and 0.01 percent of juveniles handled) (NMFS 2019).

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years. Some juvenile UWR Chinook salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, the operator releases the electrical field as soon as salmonids are observed, and most of these fish quickly recover and swim away.

Ocean rearing

UWR Chinook salmon spend 1 to 4 years in rearing in the ocean. UWR Chinook salmon are not exposed to the Proposed Action in the ocean because there are no CRS facilities or operations in these areas. Therefore, the CRS has no effect on this life stage of this ESU.

Migration of adult upper Willamette River Chinook salmon through the lower Columbia River to the Willamette River

Adult UWR Chinook salmon from all populations will be exposed to the effects of the Proposed Action from the mouth of the Columbia River to the Willamette River from January to April each year. Exposure to the Proposed Action is related to the following components of the action:

- CRS-related flood control, water management, and water quality effects from upstream operations (Bonneville Dam, the most downstream dam, is 45 miles upstream from the Willamette River confluence)
- parts of the Proposed Action that are specifically crafted to improve conditions for salmon, including flow augmentation, TDG management, predator management, the estuary habitat actions, and research and monitoring.

Operational

There are no migration barriers related to CRS operations in the lower Columbia River. Of the 13 limiting factors listed by NMFS in the 2016 status review (NMFS 2016d), only 1 is related in part to CRS operations (an altered seasonal flow regime and Columbia River plume due to water diversions and water management projects). The part of the flow regime in the lower Columbia River associated with CRS operations would be similar when comparing 2016 CRS operations and recent baseline conditions; both river flow and temperature during January through April are adequate for adult migration to the Willamette River. Any elevated TDG related to CRS operations, which is unlikely at this time of year, would not extend to the Willamette River, and therefore, any effects would be limited to the small number of adults that swim past the Willamette River. Therefore, no significant effects on UWR Chinook adult migration in the lower Columbia River are expected.

Non-operational

Predator management and monitoring actions

The pikeminnow predation management program includes the Sport Reward Fishery. This fishery can benefit juveniles, but it can affect small numbers of adults incidentally, although there would be no difference in effect when comparing 2016 operations to the recent baseline.

The Corps pinniped action at Bonneville Dam is unlikely to affect UWR Chinook salmon because most individuals migrate into the Willamette River downstream.

Research and monitoring activities

The Action Agencies' RM&E program will be similar to the current program or will be implemented at a reduced scale. NOAA Fisheries (2019); p. 79) estimated based on past reporting that, on average, the following numbers of adult UWR Chinook salmon will be affected each year during the interim period:

- No adult UWR Chinook salmon will be handled or killed during activities associated with the fish status monitoring.
- Projected estimates of adult UWR Chinook salmon handling and mortality for all other RM&E programs include (1) 174 hatchery and 149 wild adults handled, and (2) two hatchery and one wild adult killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural-origin) adult returns for the UWR Chinook salmon ESU (Bellerud 2018). NMFS (2019)[p. 79] estimates that 2.35 percent of the wild adults will be handled each year. On average, we expect that less than 1 percent of these will die after release (i.e., 0.02 percent of adults and 0.01 percent of juveniles handled).

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years. Although the exact number is unclear, some adult UWR Chinook salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be

stunned and even killed. However, the operator releases the electrical field as soon as salmonids are observed, and most of these fish quickly recover and swim away.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

Implementation of the Proposed Action will affect the volume and timing of flow in the Columbia River (compared to an unregulated Columbia River), which has the potential to alter designated critical habitat in the Columbia River mainstem and estuary for all populations in this ESU. The Proposed Action will also improve rearing habitat in the estuary, which will result in improvements in the some of the PBFs identified as essential to the conservation of the species. The PBF that could be affected by the Proposed Action is as follows:

- Freshwater migration corridors and estuarine areas – This PBF could be affected by flow changes during the spring that could affect rearing habitat in the estuary. This PBF will improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on UWR Chinook salmon in the context of existing conditions and cumulative effects. Cumulative effects are effects of future state or private activities that are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline condition (whether they are federal, state, or private). To the extent those same activities are reasonably certain to occur in the future (and are state or private), their future effects are included in the cumulative effects analysis.

Most of the effects identified in the analysis above are consistent with effects previously described for management of the CRS in past consultations. In general, the Proposed Action does not result in substantial changes in the identified effects, though there may some modest site-specific effects.

The summary below will follow the general structure of the analysis above and will discuss each factor that was previously evaluated.

Operational

Survival

Survival of juvenile UWR Chinook salmon is not affected by passage through the CRS because they enter the Columbia River downstream of the hydro projects. Juvenile Chinook salmon survival has improved in the estuary due to habitat improvements implemented by the Action Agencies. For adult UWR Chinook salmon, survival has been affected in the estuary up to (and including) the Willamette River by pinniped predators.

Future state and private actions, and the effects of climate change and variable ocean conditions have the potential to affect survival of UWR Chinook salmon. Land use activities (primarily private) have the potential to affect juvenile survival by decreasing estuary habitat or degrading abiotic factors, such as temperature. In addition, while harvest is regulated through consultation with NMFS for anadromous

fish, state agencies implement fisheries that can have a direct effect on the number of returning Chinook salmon to the UWR tributaries (and in some cases, within the tributaries themselves).

It is anticipated that survival gains that have resulted from previous actions will continue and possibly increase by continuing estuary habitat actions. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications to actions.

Travel Time

Travel times within the tributaries and estuary are not affected by the CRS. Adult travel time is not considered an issue.

It is anticipated that climate change will continue to increase overall temperatures in the Columbia River, and therefore have the potential to further affect adult UWR upstream migrational timing, and possibly juvenile emigration timing.

Continued monitoring of adult UWR Chinook salmon migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse passage proportion

Because UWR Chinook salmon do not pass through the CRS, this section does not apply to the ESU.

Water quality

Total Dissolved Gas

TDG has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high rates that resulted in GBT in juveniles and adults as they migrated through the CRS. The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

It is anticipated that during spring spill, TDG in the tailraces of CRS dams will range from 120 percent to 125 percent. This flexible spill program may slightly increase the incidence of GBT in juvenile fish. Continued monitoring of juveniles and adults for signs of GBT will inform managers on the effects of this action.

Temperature changes

Water temperatures have been modified as a result of a range of anthropogenic activities, including the existence and ongoing operation of the CRS, throughout the Columbia River Basin. Increases in temperature can have a range of effects on both juvenile and adult UWR Chinook salmon.

Ongoing non-federal land management activities that affect temperature, such as agriculture and urbanization and forestry, are not expected to improve substantially.

Implementation of the Proposed Action will continue to have minimal effect on mainstem temperatures.

Turbidity levels

Currently, sediment loads in tributaries have been affected by historic land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and rearing habitat. In the mainstem Columbia River, sediment is retained behind the dams, resulting in reduced turbidity and increased predation risk.

In the tributaries, non-federal actions are likely to continue to affect turbidity; however, improvements in tributary habitat included in the Proposed Action are expected to result in reduced sediment inputs, resulting in modest, site-specific improvements that will mitigate continued activities that degrade habitat. In the mainstem Columbia River, the current condition is not anticipated to change, and there are no non-federal activities that are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment levels in the tributaries upstream of the confluence of the Willamette River with the Columbia River. In the CRS, it is not anticipated that the Proposed Action will change the current condition.

Dam passage (adults)

Because UWR Chinook salmon do not migrate past CRS dams, this section does not apply.

Predation rates

Currently, both juvenile and adult UWR Chinook salmon encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinniped predators' prey on adults as they enter the Columbia River from the ocean to the Willamette River and upstream to Willamette Falls (and tailrace of Bonneville Dam). A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS, mostly in the tailraces of dams.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS has no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

The Proposed Action will continue to implement the predator management programs, which should ensure that predation does not worsen and may reduce overall predation rates.

Non-operational

Predation monitoring

Predation monitoring is implemented primarily to determine the effectiveness of the various predator management programs. Without this monitoring and evaluation, it would not be possible to understand whether the management programs are having the desired effect.

Monitoring predator programs is not anticipated to be affected by any non-federal actions in the future. The Proposed Action will continue to fund and implement predator monitoring and evaluation programs that have been successful to date in determining the effectiveness of the current management programs, which may harm a small number of individual UWR Chinook salmon.

Habitat actions

Currently, habitat conditions in the tributaries, mainstem Columbia River, and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect UWR Chinook salmon include continued degradation of estuary habitat and projected increased air temperature due to climate change that is warming surface water temperatures.

The Proposed Action will continue to rehabilitate habitat in the estuary.

Fish status and trend monitoring

There are potential effects from CRS-related RM&E programs on UWR Chinook salmon. These are associated with the capturing and handling of fish. RM&E activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no non-federal actions anticipated that would affect RM&E activities.

The Proposed Action will continue to implement the RM&E programs that are currently occurring, with the potential to modify these programs in the future as the results of the monitoring programs are evaluated.

Summary

The effects of the Proposed Action are summarized in Table 3-65, where the effects of the Proposed Action are compared to the current condition and designated as positive (green), no change from the current condition (gray), or designating an anticipated negative effect (yellow). This comparison helps to establish a basis for predicting future effects of the Proposed Action.

All of the actions are expected to either have no effect or result in a positive effect compared to the current condition (Table 3-65). The Proposed Action managing the CRS does not include tributary habitat improvements in spawning and rearing tributaries where UWR Chinook salmon occur, and as such, all factors within the freshwater spawning and rearing sites are not applicable. Also, UWR Chinook salmon do not migrate through the CRS and therefore, factors associated with the CRS are also not applicable. Factors associated with migration through the estuary for both juvenile and adult UWR Chinook salmon are expected to result in either a positive effect or no change. The anticipated positive effects are the result of estuary habitat improvements and predator control programs.

Table 3-65. Summary comparison of the Proposed Action to current conditions for UWR Chinook salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival	x	x	+	Habitat actions in the tributaries could increase survival.
	Travel time	x	x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes	x	x	+	Potential positive effect from continued tributary habitat restoration.
	Turbidity levels	x	x	+	Potential positive effect from continued tributary habitat restoration
	Dam passage (adults; includes fallback and overshoot)		x	+	Potential positive effect from continued tributary habitat restoration (reducing temperature)
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring	x	x	=	
Juvenile Chinook Downstream Migration Through the CRS	Survival	x		+	Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival
	Travel time	x		+	Travel time will slightly decrease with the flexible spill plan.
	Powerhouse passage proportion (juvenile)	x		+	Flexible spill plan is expected to slightly increase non-turbine passage.
	TDG levels	x		-	Spilling to revised gas cap is expected to have a negligible negative effect.
	Temperature changes	x		=	
	Turbidity levels	x		=	

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Dam passage (adults; includes fallback and overshoot)				Not applicable.
	Predation rates	x		+	Continuation of predator management programs should decrease predation.
	Hatcheries	x		=	
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Juvenile Chinook Estuary Migration and Rearing, including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates.
	Hatcheries				Not applicable
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
Adult Chinook Migration to Bonneville Dam	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds.
	Hatcheries				Not applicable
Predation monitoring		x	=		

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Fish status and trend monitoring		x	=	
Adult Chinook Migration Through CRS Dams	Survival				Not applicable
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries				Not applicable
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
	Adult Chinook Migration Upstream of the CRS to the Spawning Areas	Survival			
Travel time					Not applicable
Powerhouse passage proportion (juvenile)					Not applicable
TDG levels					Not applicable
Temperature changes					Not applicable
Turbidity levels					Not applicable
Dam passage (adults; includes fallback and overshoot)					Not applicable
Predation rates					Not applicable
Hatcheries					Not applicable
Predation monitoring					Not applicable
Fish status and trend monitoring					Not applicable

3.1.6.2 Upper Willamette River Steelhead

STATUS OF UPPER WILLAMETTE RIVER STEELHEAD DPS

This section examines the status of the UWR steelhead, the status of their critical habitat, and the effects of the Proposed Action on them. The UWR steelhead DPS was first listed under the ESA on March 25, 1999, at which time it was classified as a threatened species (64 FR 14508). That status was reaffirmed January 5, 2006 (71 FR 834), and then again on April 14, 2014 (79 FR 20802). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52630).

The status of a species is based on an assessment of extinction risk and is a function of abundance, productivity, spatial structure, and diversity; this assessment describes the species' potential for survival and recovery. Those parameters are, in part, included in listing decisions, status reviews, and recovery plans. The most recent status review used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis. Recent status reviews of the UWR steelhead by NMFS (NWFSC (Northwest Fisheries Science Center) 2015; NWFSC 2015; NMFS 2019) suggest the DPS as a whole still warrants a threatened status (Figure 3-27). The status of the critical habitat within the designated range is based on the functionality of the PBFs that are used to develop the conservation value (NMFS 2019). A brief summary of the current status of UWR steelhead is provided below.

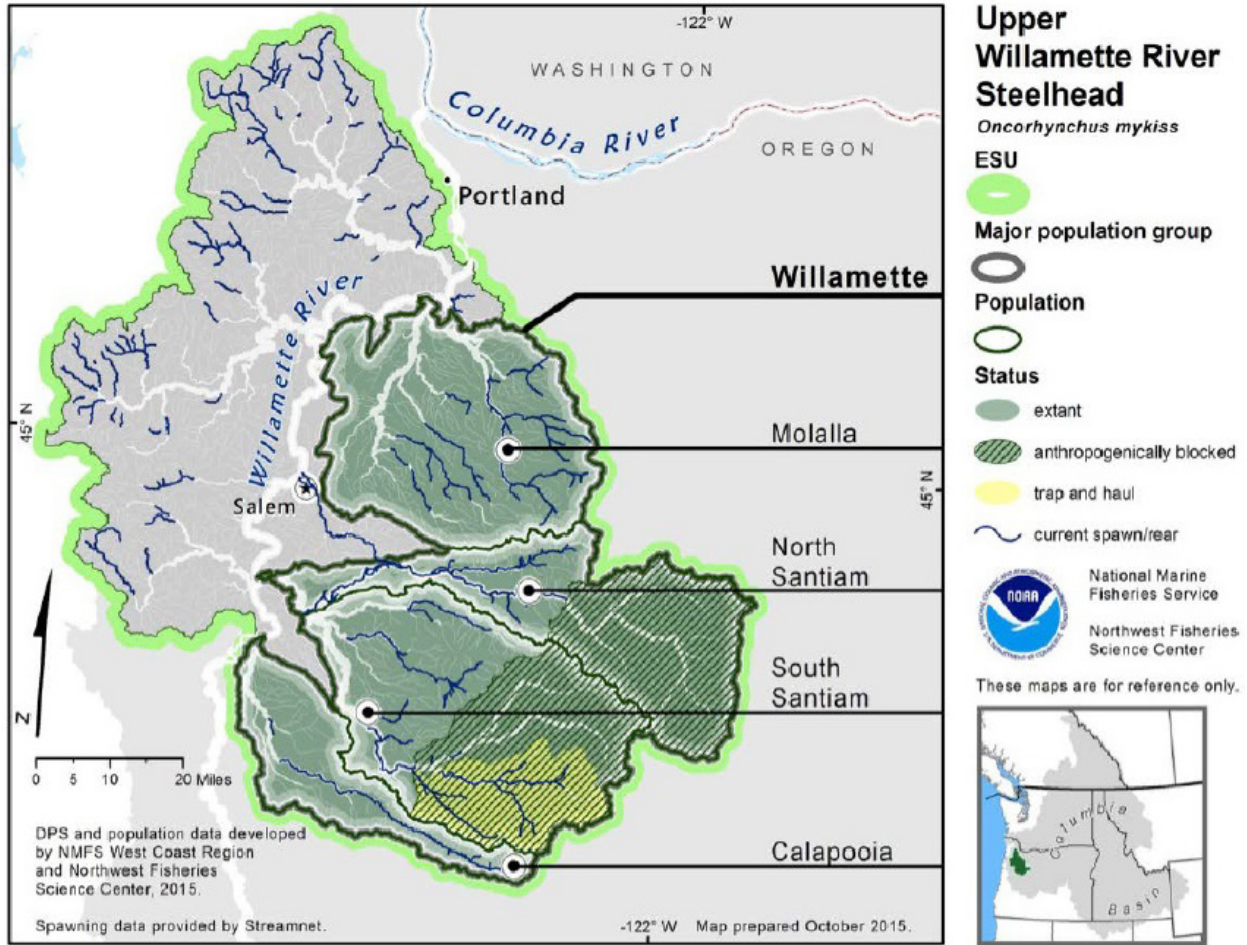


Figure 3-27. Map of UWR winter steelhead DPS spawning and rearing areas, illustrating the four populations within the one MPG [Figure 2.3-1 from NOAA Fisheries (2019)]

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 (Table 3-66). There is only one MPG in this DPS composed of four historical populations; all four populations remain extant and produce moderate numbers of natural-origin steelhead each year. Populations within this MPG include the North Santiam, South Santiam, Molalla, and Calapooia. Winter steelhead hatchery releases within the boundary of the UWR steelhead DPS ended in 1999; however, there is still a substantial hatchery program for non-native summer steelhead.

Table 3-66. UWR steelhead MPGs and populations (NWFSC (Northwest Fisheries Science Center) 2015)

Major Population Group	Populations
Willamette	North Santiam
	South Santiam
	Molalla
	Calapooia

In their most recent 5-year status review of UWR steelhead (NWFSC (Northwest Fisheries Science Center) 2015), NMFS concluded that the overall low abundance pattern observed during the previous 5-

year status review (Ford 2011) had continued through the period 2010–2015, indicating that the UWR steelhead DPS as a whole is not currently meeting the viability criteria. The most recent status update (NWFSC (Northwest Fisheries Science Center) 2015) determined that there has been no change in the biological risk category since the last reviews of these populations.

Based on their overall findings, NMFS (2019) concluded the following in their 2019 BiOp:

. . . The 2011 recovery plan (ODFW and 76 FR 65324) determined three populations to be at low risk of extinction (Molalla, North Santiam, South Santiam) and one at moderate risk (Calapooia). Since then, the DPS continues to demonstrate the overall low abundance pattern that was of concern during the last status review. The causes of these declines are not well understood, although much accessible habitat is degraded and under continued development pressure. The elimination of winter-run hatchery releases in the basin reduces hatchery threats, but nonnative summer steelhead hatchery releases are still a concern for species diversity and a source of competition for the DPS. Since 2011, it has been determined that all four populations may be at moderate risk of extinction (Ford 2011).

FACTORS AFFECTING THE STATUS OF UWR STEELHEAD

Within the upper Willamette River tributaries that support the spawning and rearing of UWR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, forestry practices and human development, including tributary dams. Impacts associated with those activities include impaired tributary fish passage and degraded freshwater habitat, including reduced floodplain connectivity and function, degraded channel structure and complexity, reduced riparian areas and large woody debris recruitment, reduced streamflow, and reduced water quality (NMFS 2019).

Factors that occur during other life phases of the UWR steelhead also have profound impacts on the status of the species and include genetic diversity effects from out-of-population hatchery releases, predation, adverse mainstem Columbia River hydropower-related effects (such as increased predation on juveniles and adults in the estuary, altered estuarine food web, and altered seasonal flow regime and plume of the mainstem Columbia River), and degraded ocean conditions (NMFS 2019).

With a decline in salmonid production, and as a result a decline in spawners within natal streams, nutrients vital to juvenile production have also decreased dramatically. Gresh et al. (2000) estimated that since 1882, the transport of marine-derived nitrogen and phosphorus loads has declined to only about 6–7 percent of historical levels. They attributed this decline to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing. These nutrients are important for salmonid production, and consequently for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2000).

The length of residency and associated mortality with UWR steelhead by life stage illustrates that for UWR steelhead, the greatest incidence of mortality occurs where these fish spend most of their life (i.e., tributary and ocean residence). Tributary survival of juvenile steelhead varies depending on habitat and

climate conditions, and the carrying capacity of the natal stream (Thurow 1987; Chapman et al. 1994). Quinn (2005), using average values from more than 200 studies, found that egg-to-emigrant (smolt) survival for steelhead averages 1.4 percent. Smolt-to-adult survival is not available for this DPS.

Because the Willamette River enters the Columbia River downstream of Bonneville Dam, there are no estimates of passage survival through the CRS for this DPS.

Below, we discuss factors affecting the status of UWR steelhead by life stage.

Freshwater spawning, rearing, and migration to the CRS

UWR steelhead use freshwater tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. While many of the habitat modification are relics of past anthropogenic practices, NMFS (2019) identified factors limiting viability in the upper Willamette River in tributary areas that continue to influence productivity. The DPS is limited by one or more of the following factors: (1) climate change effects, including projected increased stream temperatures, projected changes in precipitation/streamflow, and years of low ocean productivity; (2) ongoing development of low-elevation freshwater habitats in private ownership, which further contributes to degraded freshwater habitat, degraded water quality, lower instream flows in summer and early fall, and increased disease incidence; (3) reduced peak flows and altered flows in Willamette mainstem and North and South Santiam Rivers due to the hydropower/flood management system; (4) reduced access to spawning and rearing habitats due to impaired adult and juvenile passage at North and South Santiam Dams; and (5) interbreeding and competition with non-native summer steelhead hatchery releases and residualized winter steelhead.

The consequences of long-term habitat degradation are likely reducing overall habitat capacity for this species. The ISAB (2015) provided evidence for strong density dependence at current abundance levels for anadromous salmon and steelhead and suggests that habitat capacity has been greatly diminished. Density dependence was observed in most rivers where data have been examined and includes 26 of 28 interior Columbia River Basin Chinook salmon populations, and in all 20 interior Columbia River Basin steelhead populations despite natural spawners being much less abundant currently relative to historical abundance (ISAB 2015).

In an assessment of density dependence using a two-stage Gompertz model, Hinrichsen and Paulsen (2019) found evidence of density dependence at both the spawner-to-parr and parr-to-adult life stages and concluded that due to density dependence during the parr-to-adult stage, a greater number of fish reaching the ocean may not substantially increase the number of adults reaching the spawning grounds. Based on this evidence, the authors concluded the following:

This suggests that life cycle modeling to date has been overly optimistic about the benefits of survival rate increases in the hydrosystem and elsewhere to improve the viability of salmon populations threatened with high extinction risk.

While the modeling framework of Hinrichsen and Paulsen (2019) was applied to SR spring/summer Chinook, the results are consistent with the 2015 ISAB report, and therefore, it is reasonable to assume that steelhead are also experiencing similar effects of density dependency.

Past and present effects of the existence of CRS dams and operations: UWR steelhead are not exposed to the CRS facilities or operations during adult holding, spawning, egg incubation, and juvenile rearing and migration within the tributary environment.

Past and present effects of hatcheries: Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They can also help preserve genetic resources until factors limiting natural productivity 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.

Winter-run steelhead hatchery programs were terminated in the late 1990s in the upper Willamette River. Currently, the only steelhead hatchery program in the upper Willamette River releases summer steelhead originally taken from Skamania Hatchery on the Washougal River from the LCR steelhead DPS. Adult summer steelhead typically return to the upper Willamette River Basin between March and October, and spawn timing can overlap with native winter steelhead, raising concerns about negative ecological interactions and genetic introgression with native winter steelhead in the upper Willamette River (Johnson et al. 2013; Harnish et al. 2014; McMichael et al. 2014; Jepson et al. 2015).

Juvenile UWR steelhead downstream migration through the CRS

Because this DPS does not spawn above Bonneville Dam, juveniles will not travel through the CRS. Therefore, this section does not apply to UWR steelhead.

Juvenile UWR steelhead estuary migration and rearing, including the plume

The estuary provides important migratory habitat for UWR steelhead populations. Since the late 1800s, 68 to 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 (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). 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 (ERTG 2019). For a more detailed discussion of estuary and plume conditions, please see NMFS (2019).

Past and present effects of CRS existence and operations: While there are no CRS facilities in the estuary, past operations of CRS dams affected the timing and volume of flows, as well as water quality in this area. However, the influence is generally attenuated below Longview, WA by the distance from the dams, inflow from other tributaries joining the Columbia River, and multiple other dams and diversions within the basin that also affect flows and water quality in the estuary. The reduction in flows and associated sediment recruitment downstream from Bonneville Dam have likely limited the occurrence of some downstream habitat forming processes.

Estuarine floodplain habitat is important for outmigrating juvenile salmon and steelhead, including UWR steelhead. To help maintain and improve the overall status of salmon and steelhead in the Columbia River Basin, the Action Agencies actively work to restore and conserve habitat in the Columbia River

estuary through the CEERP. These restoration actions affect salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit of estuary restoration is that wetland food production supports foraging and growth within the wetland [Johnson et al. (2018) as cited in NMFS (2019)]. Prey items [primarily chironomid insects and corophiid amphipods; PNNL/NMFS (2018) as cited in NMFS (2019)] produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Restoration actions in the estuary, such as those highlighted in the latest 5-year review of the CEERP, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide-gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity below Bonneville Dam [Johnson et al. (2018) as cited in NMFS (2019)]. In addition to the acres restored, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Past and present effects of predation management: A variety of avian species (especially Caspian terns and double-crested cormorants), have historically been a major source of predation on juvenile salmonids in the estuary. While avian predators continue to prey upon juvenile salmonids, including UWR steelhead, predation rates have declined because of a variety of management efforts. For example, between 2007 and 2010, the average predation on UWR steelhead by Caspian terns and double-crested cormorants from East Sand Island (near the mouth of the Columbia River) was approximately 15 percent and 10 percent, respectively (Evans et al. 2018). However, from 2011 to 2017, the average for Caspian terns dropped to 9.1 percent, and 5.5 percent for double-crested cormorants (Evans et al. 2018). The efforts to reduce avian predation are discussed in detail in the 2019 BiOp and are incorporated by reference here (NMFS 2019). NMFS (2019) noted the success of implementing the avian management plans at meeting underlying goals; however, the results may be uncertain at this time, because avian predators have relocated to other areas within the estuary.

Ocean Rearing

UWR steelhead typically spend 1 to 2 years rearing in the ocean (NMFS 2009). Variability in marine ecosystem productivity can be the major factor determining adult steelhead run size (NMFS 2014a). In the most recent adult return years since about 2014, abnormally warm ocean temperatures and subsequent poor ocean conditions have contributed to declines in ocean survival and associated adult returns. In the 2019 BiOp, NMFS provides a detailed discussion of ocean conditions, factors that affect the ocean environment, and impacts on UWR steelhead; that information is incorporated here by reference. A brief summary of those factors is provided below.

Factors that influence ocean productivity are also likely to affect survival of UWR steelhead. Factors such as projected increased air temperature due to climate change, which will likely increase water temperature and alter productivity, severe El Niño events, ocean acidification, and major alterations in the northeast Pacific marine ecosystem associated with the PDO (NMFS 2019) will affect survival, either directly or indirectly, because of deleterious impacts on marine food webs.

Abnormally warm ocean temperatures and subsequent poor ocean conditions have also contributed to shifts in marine distribution. Many species that typically only occur in more southerly waters, moved northward from southern California to Alaska during the unusually warm water in 2014 and 2015, which

was referred to as “The Blob.” Similar range extensions for a variety of marine species have also been observed during years of severe El Niño events [Percy (2002) and Fisher et al. (2015) as cited in NMFS (2019)]. These shifts in species distribution likely disrupt the marine ecosystem in ways that negatively affect salmon and steelhead survival by modifying the composition, distribution, and abundance of their primary prey species.

Past and present effects of CRS existence and operations: There are no CRS facilities in the ocean and past CRS operations have had no direct effect on this DPS during ocean residence. In a recent review, Welch et al. (2018) concluded that marine survival of West Coast Chinook and steelhead populations has collapsed over the last half century for most regions of the West Coast:

We found that marine survival collapsed over the past half century by a factor of at least 4-5 fold to similar low levels (~1%) for most regions of the west coast. The size of the decline is too large to be compensated by freshwater habitat remediation or cessation of harvest, and too large-scale to be attributable to specific anthropogenic impacts such as dams in the Columbia River or salmon farming in British Columbia.

Another factor that should be considered is delayed, or latent, mortality. Delayed mortality is a term for harm caused when an animal survives one event or circumstance but incurs damage that only shows up later and may be expressed as illness or death. With Columbia River Basin salmon and steelhead, the term is commonly applied in situations such as barging or dam passage of salmon or steelhead smolts. The term “latent mortality” is generally used more specifically to apply to the effects of dam passage. While most or all of the fish might survive the act of barging or safely pass the dam, the delayed mortality hypothesis holds that a smolt is less healthy than it would be otherwise and therefore less likely to survive in the ocean and return as an adult.

After reviewing various studies, the ISAB (2012) concluded that their analyses demonstrated that fish bypass systems are associated with some latent mortality, but the factors responsible for latent mortality remain poorly understood and are inadequately evaluated. Further:

The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis).

Past and present effects of harvest: Harvest of steelhead in the ocean is rare (NMFS 2019).

Adult steelhead migration to the Willamette River

Adult steelhead migrating upstream after ocean residence typically do not feed within the freshwater environment. Instead, they depend on stored energy reserves as they migrate upstream to spawn. During their upstream migration, they require cool, clean water of adequate volume, and a migratory corridor free of obstructions to access spawning areas (NMFS 2019). Populations of UWR steelhead enter the Columbia River in January through April, pass Willamette Falls from mid-February to mid-May, and spawn in March through June (ODFW and NMFS 2011).

For upstream migrating UWR steelhead, the primary factor affecting survival in the Columbia River to the Willamette River is pinniped predation. California and Steller sea lions prey on adult steelhead throughout the lower Columbia River. 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. The ODFW has documented an increase of monthly counts of California sea lions hauling out at the East Mooring Basin in Astoria, Oregon, during the month of September. For the years of 2008 to 2014, the number of California sea lions observed averaged less than 500 animals; for 2015 and 2016 that average increased to more than 1,000 individuals (NMFS 2019). Data collected by ODFW observers at Willamette Falls estimates that California sea lions preyed on adult UWR steelhead in 2018, and Steller sea lions preyed on additional UWR steelhead adults in the same year.

Past and present effects of CRS dams and operations: There are no CRS dams that impede migration in the lower Columbia River as these fish migrate upstream to the Willamette River. As previously mentioned, adult UWR steelhead enter the Columbia River from January through April, and therefore, while the Action Agencies are required to spill water over the CRS dams to increase survival of juvenile fish migrating downstream, the timing does not coincide with UWR steelhead migration in the lower Columbia River. So, adults will not be exposed to higher levels of TDG, which could influence their migration behavior or increase their chances of GBT (NMFS 2019). Besides, TDG levels are mitigated to some extent downstream from Bonneville Dam because of gas dissipation and mixing of water with lower TDG levels from tributaries such as the Willamette River. Furthermore, 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 (NMFS 2019).

Past and present effects of harvest: Harvest mortality in fisheries downstream of Bonneville Dam have been reduced substantially in response to evolving conservation concerns and restrictions for ESA-listed species. Historically, UWR steelhead were harvested in both non-treaty and treaty commercial fisheries, as well as in recreational fisheries. In response to declining steelhead abundance, non-treaty commercial harvest of steelhead was prohibited in 1975, and treaty commercial harvest has been reduced and restricted to clipped (hatchery-origin) fish. As such, the harvest of non-clipped fish is incidental. Also, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986.

Adult steelhead migration through CRS dams

Because the UWR steelhead DPS does not migrate through the CRS, this section does not apply to UWR steelhead.

Adult steelhead migration upstream of the CRS to the spawning areas

Within the upper Willamette River tributaries that support the spawning and rearing of UWR steelhead populations, a variety of limiting factors affect both the species and their habitat. Processes such as climate change have contributed to altered water quality and quantity. Other activities have resulted in habitat degradation. Those activities include agriculture, tributary dams, forestry practices, and urban and rural development. Impacts associated with those activities include (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 streamflow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition (NMFS 2019).

Past and present effects of predator management: As previously discussed, there has been a large increase in the number of California sea lions and Steller sea lions that are entering lower Columbia River and feeding on adult salmon and steelhead. Some of the California sea lions that enter the Columbia River make their way up the Willamette River and feed on adult salmonids attempting to find passage over Willamette Falls. In the mid-1990s observations of California sea lions in the Willamette River began to increase where they often foraged for winter steelhead and spring Chinook salmon below the fishways at Willamette Falls (128 miles upstream from the ocean). ODFW began monitoring sea lion occurrence and predation on salmonids at the falls beginning spring 1995. Continuing through 2003, results from these observations showed that sea lions at the falls generally numbered a dozen or fewer animals each year, and predation losses were generally a few hundred fish or fewer. In addition, the trend in predation activity appeared to be flat or declining, whereas winter steelhead runs were increasing. Anecdotal information and informal surveys conducted by Portland State University suggested that after ODFW surveys ended in 2003, predation of salmonids at the falls was continuing and increasing (Wright et al. 2018). ODFW began monitoring sea lion predation again in 2014.

Past and present effects of harvest: There is no directed fishery for winter steelhead in the upper Willamette River. Due to differences in return timing between native winter steelhead, introduced hatchery-origin summer steelhead, and hatchery-origin spring Chinook salmon, the encounter rates for winter steelhead in the recreational fishery are thought to be low. Sport fishery mortality rates were estimated to be 0 to 3 percent (Ford 2011). There is additional 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). Tribal fisheries occur above Bonneville Dam and do not affect UWR steelhead (NWFSC (Northwest Fisheries Science Center) 2015).

STATUS OF CRITICAL HABITAT

In this section of the BA, the status of critical habitat is reviewed for UWR steelhead. Critical habitat includes the stream channels within designated stream reaches and to an extent is defined by the ordinary high-water mark (33 CFR § 319.11). The PBFs of critical habitat that are essential to the conservation of UWR steelhead include freshwater spawning, rearing and migration corridors, as well as estuarine and nearshore marine areas (Table 3-67) (NMFS 2019).

Critical habitat for the UWR steelhead DPS was designated on September 2, 2005 (70 FR 52630). Critical habitat has been designated for populations of UWR steelhead in the upper Willamette River subbasin, North Santiam River subbasin, South Santiam River subbasin, Middle Fork Willamette subbasin, Yamhill subbasin, Molalla/Pudding subbasin, Tualatin subbasin, and the lower Willamette/Columbia River Corridor (NMFS 2008a).

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation 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 UWR steelhead.

Table 3-67. PBFs and components and principal factors affecting the environmental baseline of critical habitat designated for UWR steelhead [reproduced from NMFS (2019); Table 2.3-3; pages 102–103]

PBF	Components of the PBF	Principal Factors Affecting Environmental Baseline Condition of the PBF
Freshwater spawning	Substrate, adequate water quality and water quantity	Concerns about access to spawning sites, substrate quality, water quality
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 supporting juvenile development 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	Concerns about water quantity, temperature, access to rearing habitat, lack of complex rearing habitat
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting)
Estuarine areas	Free of obstruction and excessive predation, with water quality, water quantity, 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
Nearshore marine areas	Free of obstruction and excessive predation, with water quality and quantity conditions and forage	Concerns about increased opportunities for pinniped predators and adequate forage

All steelhead spawn in gravel and cobble substrates that are largely free of fine sediments. Developing eggs require cool, clean, and well-oxygenated waters for proper development. Juvenile UWR steelhead usually spend 2 years in freshwater but may remain longer depending on water temperature and growth. Juvenile migration to the ocean occurs during the spring freshet during the months of March through mid-June (NMFS 2019).

During their freshwater residence, juvenile salmon need abundant food sources and instream cover to protect them from predators. Juvenile fish cover may include undercut banks, overhanging vegetation, logs and root wads, and large substrate (NMFS 2019). Off-channel habitat, side channels, and other low stream velocity areas provide refuge during high flow event. Cool waters offered by springs, seeps, and deep pools offer refuge when stream temperatures increase during the summer. Interstices offered by large substrate allow juveniles to seek refuge during the winter.

Freshwater spawning and rearing sites

Freshwater spawning and rearing areas have been designated as essential for the conservation of UWR steelhead. Spawning and rearing occurs in the North Santiam, South Santiam, Molalla, and Calapooia River Basins. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some or high potential for improvement (NMFS 2019). The quantity and quality of the remaining spawning and rearing habitat has been significantly degraded by multiple factors. The existence of the federal dams in the major tributaries has blocked access to a substantial proportion of the historical habitat and has adversely affected habitats downstream. The best quality habitat is located in the headwater areas, and many of these areas are not accessible to fish because of the impassable dams. The dams also have major impact in terms of flow, water temperature regime, downstream sediment and large wood transport, and channel complexity (NMFS 2008a).

The quality of tributary habitat for UWR steelhead varies substantially throughout the upper Willamette River region; some spawning and rearing habitat is in near pristine condition, while other areas are minimally to highly degraded because of past human activities (NMFS 2019). Habitat throughout the interior Columbia River Basin tributaries has been degraded by several activities, including 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, timber harvest, mining, and urbanization [Lee et al. (1997) as cited in NMFS (2019)]. These activities have led to factors that limit the viability of UWR steelhead. These factors include (1) impaired fish passage (including tributary dams); (2) reduced stream complexity and channel structure; (3) lack of fine sediment; (4) the increase in TDG; (5) elevated summer water temperature; (6) diminished streamflow during critical periods; (7) reduced floodplain connectivity and function; and (8) degraded riparian condition (NMFS 2008a).

Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel instability are common symptoms of ecosystem decline in areas of critical habitat. Lack of adequate summer streamflows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas of the interior Columbia River Basin. Large-scale habitat assessments in the interior Columbia River Basin indicate that in watersheds managed for natural resources extraction, the number of large pools has decreased from 87 to 20 percent [McIntosh et al. (1994) as cited in NMFS (2019)].

The Proposed Action managing the CRS does not include tributary habitat improvements in spawning and rearing tributaries where UWR steelhead occur.

The ISAB (2015) has pointed out that there is compelling evidence for strong density dependence at current abundance levels for anadromous salmonids and suggests that habitat capacity has been greatly diminished. The ISAB also suggests that changes in environmental conditions within habitats accessible to salmon and steelhead stemming from climate change, chemicals, and intensified land use appear to have further diminished habitat capacity. The ISAB (2015) found that density dependence was observed in all 20 interior CR steelhead populations during the 1980 to 2008 brood years.

The ISAB (2015) has noted that studies of density dependence during the spawning and incubation stage are rare and that habitat-related density independent effects like sedimentation, streamflow, water temperatures, and winter freezing conditions can be responsible for significant mortality during

spawning and incubation. The ISAB (2015) concludes by stating that both the UCR and Snake River Basin steelhead DPSs show a strong density-dependent recruitment of adults. And while few studies have examined the main cause of the observed density dependence (i.e., limitations in spawning vs. rearing habitat), density dependence in steelhead is expected to be related to interactions during rearing more so than during spawning stages; further study is necessary to confirm this.

Key recommendations from the ISAB (2015) included (1) account for density effects when planning and evaluating habitat restoration actions; (2) establish biological spawning escapement objectives that account for density dependence; (3) balance hatchery supplementation with the river basin's capacity to support existing natural populations by considering density effects on the abundance and productivity of natural-origin salmon; and (4) improve capabilities to evaluate density dependent growth, dispersal, and survival by addressing primary data gaps.

Freshwater migration corridors

The tributary migration corridor extends from the spawning and rearing areas in the upper Willamette River subbasins downstream to the Columbia River plume. Migration corridors are considered essential to the conservation of UWR steelhead. Human activities that have affected habitat in subbasin tributary reaches have already been discussed and contribute to the quality and quantity of water downstream and within the migration corridor of the Willamette and Columbia Rivers. Tributary habitat actions already implemented support UWR steelhead and include protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, removing barriers to spawning and rearing habitat, and other actions targeted toward addressing limiting factors (NMFS 2019). No CRS projects exist in the freshwater tributary corridor (Willamette River and tributaries), and UWR steelhead are not exposed to any effects from the operation of the CRS until they reach the mainstem Columbia River.

The quality of designated critical habitat within the lower Columbia River migration corridor is a function of the cumulative impacts of upstream actions, including impacts from development along the corridor, dam operations, and management within the Columbia River that affect both juvenile and adult UWR steelhead. All these factors combine to affect critical habitat in the mainstem and influence the migration corridor. Habitat within the mainstem lower Columbia River has been substantially altered by a number of factors, including basin-wide water management, the existence and on-going operations of CRS hydroelectric projects, increased avian and pinniped predators, the introduction of non-native species, and other human-related activities that have degraded water quality and habitat (NMFS 2019). Within the 2019 BiOp, NMFS describes the factors affecting the behavior and survival of UWR steelhead downstream of the CRS, and that information is included here by reference (NMFS 2019).

Estuarine and nearshore marine areas

Critical habitat has been designated for UWR steelhead in the Columbia River estuary (NMFS 2019). NMFS has defined the estuary to include the reach where river flows interact with tidal forces. As defined, that area includes the lower Columbia River from the Bonneville Dam tailrace (RM 146) to the mouth of the Columbia River, and includes tributaries influenced by tidal action. As such, the lower 26 miles of the Willamette River is included within the estuary domain.

NMFS (2019) considers a functioning estuary to be essential to the conservation of UWR steelhead. Furthermore, they identified the PBFs for UWR steelhead in estuaries to include areas free of obstruction with water quality, quantity, and salinity conditions that support 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.

Degraded habitat conditions in estuarine and nearshore marine areas were identified as limiting factors for UWR steelhead (NMFS 2019). Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The Columbia River estuary was dynamic; it was maintained and influenced by winter and spring floods, low flows in late summer, large woody debris, and a shallow bar at the mouth of the Columbia River (NMFS 2019). As reported by NMFS (2019), the current conditions of the Columbia River estuary have changed as a result of dredging to deepen and maintain navigation channels, while jetties and pile-dike fields have been constructed to stabilize and concentrate streamflow for navigation. Marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. As noted by NMFS, the mouth of the Columbia River was historically about 4 miles wide but has decreased to about 2 miles wide, and the depth has increased at the Columbia River channel at the bar from less than 20 feet to more than 55 feet (NMFS 2019).

The estuary provides important migration habitat for UWR steelhead. NMFS (2019) reported a dramatic decrease in wetland areas associated with the Columbia River estuary. More than 50 percent of the marshes and spruce swamps have been converted to industrial, transportation, recreational, agricultural, or urban areas, and more than 3,000 acres have been converted since 1948 (NMFS 2019). In the upper reaches of the estuary, many wetlands along the shore have been converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost since the late 1800s. Those wetlands support salmonid food webs both in shallow water and for larger juveniles migrating in the mainstem.

Changes in streamflow and sediment delivery have also affected critical habitat in the Columbia River estuary. NMFS reports that water storage and release patterns from reservoirs upstream have changed the seasonal pattern and volume of discharge within the Columbia River estuary (NMFS 2019). Discharge has increased in the winter and peak spring/summer floods have been reduced. NMFS (2019) also reports that model studies indicate that combined human activities in the Columbia River Basin have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50 percent or more. The significance of changes in sediment delivery to UWR steelhead is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean [Johnson et al. (2018); PNNL/NMFS (2018); and Weitkamp (2018) as cited in NMFS (2019)].

There are no CRS-related barriers to migration in this reach, and there is no evidence that flows are insufficient for migration.

Proposed Action Components Specific to UWR Steelhead

The Proposed Action, continuing to operate and maintain the CRS and implement associated mitigation, is fully described in Chapter 2 of this document and associated appendices as modified by the flex spill Letter to the National Oceanic and Atmospheric Administration (NOAA). Reclamation is also consulting on the Columbia River mainstem effects of six irrigation projects that also have additional and separate ESA reviews.²⁹ The Proposed Action continues extensive operations that benefit UWR steelhead, including flow augmentation. In addition, mitigation activities that have been implemented as part of previous BiOps will continue, including estuary habitat improvements and fish, avian, and pinniped predator management, as described in Chapter 2 of this document. The Action Agencies will continue to coordinate with regional sovereigns and will regularly update the water management, fish passage, fish operations, and water quality plans. The Action Agencies intend to implement these actions commencing in September 2020 and continuing until a regulatory re-initiation of consultation trigger is met.

UWR steelhead are exposed to the CRS operations in the following ways:

- streamflow quantity and TDG changes from the Willamette River confluence with the Columbia River to the ocean.

Mitigation that is part of the action includes flow augmentation; spill regimes at eight dams; cool water releases from Dworshak Reservoir during the summer migration period; juvenile fish transportation; fish facility operations at eight dams (bypasses, ladders, surface structures, outfalls, etc.); fish friendly turbines at McNary and Ice Harbor Dams; and avian, fish, and pinniped predator management.

EFFECTS OF THE ACTION ON UWR STEELHEAD

The effects of the existence of the dam and reservoir system, and past operations, are part of the baseline and are not considered effects of the Proposed Action. Already-completed actions will continue to provide benefits in the future. The effects of the Proposed Action on this DPS and its critical habitat are described by life stage below.

Freshwater spawning, rearing, and migration to the CRS

In the spawning and rearing areas, fish are not exposed to the effects of the CRS because no operations (e.g., flood risk management, irrigation, power generation) occur in these areas. Because there is no exposure to these operations that are components of the Proposed Action, there are no direct effects on individual fish in these areas.

Tributary actions are not part of the Proposed Action and are not discussed further in this section.

²⁹ Columbia River mainstem effects of certain Reclamation irrigation projects are included in this CRS consultation because the Columbia River hydrologic modeling incorporates all such impacts. The mainstem Columbia River impacts are included for the Yakima, Umatilla, Deschutes, and Crooked River irrigation projects. The flow impacts of these projects on the mainstem Columbia River are fully integrated in discussions of flow and TDG in the parts of the migratory corridor both used by this DPS and affected by these projects.

Juvenile steelhead downstream migration through the CRS

Juvenile UWR steelhead are exposed to the effects of CRS operations once they reach the mainstem Columbia River down to the estuary. In this migration corridor, juvenile UWR steelhead will continue to experience the deleterious impacts of a degraded environmental baseline and associated cumulative effects. Because juvenile UWR steelhead do not migrate through the CRS, this section does not apply to UWR steelhead.

Juvenile Steelhead Estuary Migration and Rearing, Including the Plume

Estuarine and nearshore ecosystems provide habitat for juvenile steelhead to forage and avoid predators. Most juvenile steelhead move through the estuary in 1 or 2 days, and survival in this reach appears to be high (Daly et al. 2014), excluding mortality associated with avian predation.

Construction and operations of the CRS have led to changes in the hydrograph, TDG, and the amount of sediment and large wood deposited in the estuary. However, the effects of CRS water management in the estuary are generally attenuated below Longview, WA by the distance from the facilities and inflow from tributaries like the Willamette and Cowlitz Rivers. Thus, any direct impacts from flow or elevated TDG in this area are expected to be minor.

Continuing avian predator management in the estuary will benefit this DPS by reducing the number of individuals of this DPS eaten by birds in the estuary [e.g., see Figures 50 and 52, Corps et al. (2017a), Section 1].

A more detailed analysis of the effects of the Proposed Action on UWR steelhead is provided below. The indicators that will be used to determine the effects of the Proposed Action on juvenile steelhead migration through the estuary and plume include the following:

- operational
 - survival
 - fish travel time
 - TGD levels
 - temperature changes
 - turbidity
 - predation rates
- Non-operational
 - predation monitoring
 - estuary habitat actions
 - fish status and trend monitoring

Operational

Survival – Survival is likely not influenced by operations.

Fish travel time – Proposed changes in water management are not expected to substantially increase flows downstream of Bonneville Dam, and therefore, the factors that currently influence fish travel time to the estuary are not likely to change.

TDG levels – As mentioned previously, GBT was historically a major factor in juvenile salmonid mortality prior to the Corps installing spillway gas abatement structures at each mainstem dam, which reduced the supersaturation of the water by ensuring that the water did not plunge to depth and force gas into saturation (NMFS 2019). Elevated TDG levels during periods of increased spill downstream until attenuated at RM 110.

Temperature changes – As mentioned above, very little change in temperature is expected under the Proposed Action upstream of Bonneville Dam. The same is anticipated to be true for the reach from Bonneville Dam to the estuary.

Turbidity – As mentioned previously, it is not anticipated that the Proposed Action will have much of an effect on turbidity in the CRS, including the section of the mainstem river from Bonneville Dam to the estuary.

Predation rates – The Proposed Action is not anticipated to change the rate of predation of juvenile salmonids in the Columbia River. Continuing to implement the Caspian tern and cormorant management plans, and the NPMP will result in negligible changes in predation and will prevent the impacts from “backsliding” to levels that were occurring prior to the Action Agencies implementation of these plans.

Non-Operational

Predation monitoring – The Proposed Action will continue to implement the various predator management programs and their monitoring components that are currently being implemented in the estuary and mainstem Columbia River. Some ESA-listed salmon and steelhead are captured as part of implementing the Pikeminnow Sport Reward Fishery and dam angling program. The number of individual UWR steelhead affected is likely to continue at a similar rate in the future. While the numbers are low across the entire program (NMFS estimated that no more of the DPS than 10 adults and 20 juvenile steelhead would be caught), some individuals below Bonneville Dam may be captured, injured or killed.

Estuary Habitat Actions – As part of the Proposed Action, the Action Agencies will continue implementing the CEERP to improve estuarine habitat and tidally influenced portions of tributaries used by anadromous salmon and steelhead. The planned improvements in habitat functions are expected to provide long-term benefits to native species that use these habitats, through improved ecological functions and processes. Appropriate ESA consultation is typically undertaken prior to implementation of these projects at the site-specific scale. These ESA consultations are complete with ITS and implanting Terms and Conditions with which the Action Agencies comply. Implementation of the Proposed Action will continue habitat restoration efforts that are benefiting juvenile salmonids. Project effectiveness is expected to increase over time as they mature and new ones are implemented.

Fish status and trend monitoring – One aspect of the CEERP is to monitor the effectiveness of restoration actions and conduct research to address critical uncertainties. Adaptive management is used to guide program goals and actions (Johnson et al. 2018), and RM&E will continue under the Proposed Action. As illustrated above, the CEERP is benefiting salmonids, both in the juvenile and adult life-history stages.

Ocean Rearing

During ocean residence, mortality of anadromous salmonids can be very high, and variability in marine ecosystem productivity can drive adult salmon returns (NMFS 2014a; U.S. v. Oregon 2018; NMFS 2019). Of the factors that influence ocean productivity, which have been linked to salmonid growth and survival, the most influential is the Pacific Decadal Oscillation. However, other processes also contribute to ocean productivity such as the Northern California Current, the North Pacific Gyre Oscillation, the El Niño Southern Oscillation, climate change, and ocean acidification (NMFS 2019). All these factors will affect survival, either directly or indirectly, because of the deleterious impacts on marine food webs.

The proposed action will have no effect on the marine habitats used by UWR steelhead for growth and maturing because there are no CRS operations that affect this area. However, a small number of individual salmon and steelhead will experience the range of deleterious effects from capture and handling from Bonneville-funded RM&E activities investigating salmon and steelhead, including SRB steelhead, in the nearshore ocean environment.

Adult steelhead migration to the Willamette River

While no indices of migration rate from coastal waters to the Willamette River exist for UWR steelhead, it is known that UWR steelhead enter the Columbia River from January through April and pass Willamette Falls from mid-February to mid-May. Based on this information, steelhead appear to migrate fairly rapidly from the estuary to the Willamette River. CRS operations can generally result in negligible changes in flow and TDG levels in the estuary. It is anticipated that during periods of increased spill each spring, elevated TDG levels will extend about 35 miles downstream from Bonneville Dam (NMFS 2019). However, TDG will be attenuated within the lower Columbia River by the distance from the facilities and the streamflows from lower river tributaries like the Willamette River. The Proposed Action causes no adult migration barriers for UWR steelhead adults downstream of Bonneville Dam, and streamflow is sufficient for adult migration. CRS operations do not affect water temperature in this part of the Columbia River because local, regional, and annual climate and streamflow conditions, combined with lower Columbia River tributaries, override any impact of operations. As noted earlier, pinniped predation negatively affects adult migration within this reach, an effect not caused by CRS operations. Thus, the Proposed Action is likely to have negligible effects on UWR steelhead adult migration from the ocean to the Willamette River.

Operational

Travel Time – The Proposed Action is not expected to alter the migration rate of adult UWR steelhead in the lower Columbia River downstream from Bonneville Dam. While the Proposed Action will result in negligible flow reductions and water particle velocity at the time late-migrating adult steelhead will be

entering and migrating through the lower Columbia River, this reduction is not expected to result in any increase or decrease in migration rate.

TDG – The Proposed Action includes a flexible spill component, which during spring spill operations will result in spill at CRS projects to a level where the state water quality limit for TDG is met 16 hours per day, and the performance spill component totals 8 hours per day. As such, TDG levels will reach 120 percent of saturation during the 16-hour block, and a lesser amount during the performance spill component. Furthermore, it is anticipated that the gas cap of 120 percent for the 16-hour block will increase to 125 percent in 2020. Based on these operations and their earlier run timing, it is anticipated that most adult UWR steelhead will not be exposed to slightly elevated TDG levels.

Elevated levels of TDG can increase the likelihood of GBT in adult and juvenile salmonids, which can injure or kill afflicted individuals. To offset the extent of gas supersaturation at CRS projects, the Corps has installed gas abatement devices within the spillways to reduce TDG levels.

Based on the attenuating effect of the distance downstream of the system, the influence of tributary streamflow, and the run timing of UWR steelhead, the Proposed Action is not expected to have measurable effects on this DPS downstream from Bonneville Dam.

Temperature – Because actions associated with the Proposed Action will not result in elevated water temperatures downstream from Bonneville Dam, the effects of the Proposed Action are not expected to negatively affect adult UWR steelhead within this reach.

Turbidity – Because actions associated with the Proposed Action are not expected to result in changes in sediment load downstream from Bonneville Dam, the Proposed Action is not expected to negatively affect adult UWR steelhead within this reach.

Non-Operational

Predation – No components of the Proposed Action are expected to result in a change associated with pinniped predation.

Adult steelhead migration through CRS dams

Because adult UWR steelhead do not migrate through the CRS, this section does not apply to UWR steelhead.

Adult steelhead migration upstream of the CRS to the spawning areas

Implementation of the Proposed Actions will have no effect on UWR steelhead tributary habitats.

EFFECTS OF THE ACTION ON CRITICAL HABITAT

The effects of the Proposed Action on critical habitat are discussed in this section. Effects on critical habitat were assessed based on the elements of the Proposed Action that are likely to affect the PBFs essential for the conservation of the UWR steelhead DPS. Effects on designated critical habitat include the Proposed Action and associated mitigation that affect habitat within the freshwater migration corridor and estuarine areas.

Freshwater spawning and rearing sites

Because freshwater spawning and rearing sites are not affected by the Proposed Action, this section does not apply to UWR steelhead.

Freshwater migration corridors

Freshwater migration corridors are used by returning adult steelhead migrating downstream of the CRS and by juvenile steelhead migrating downstream from the confluence of the Willamette River with the Columbia River. The CRS dams and reservoirs have and will continue to affect the PBFs associated with UWR critical habitat within the mainstem Columbia River downstream of the confluence with the Willamette River. Ongoing implementation of the Action Agency's predator management programs should improve the passage feature by reducing the consumption of juvenile and adult salmon within the CRS, including areas downstream of Bonneville Dam. These programs will continue to reduce the risk of predation on UWR steelhead.

Estuarine and nearshore marine areas

Estuarine and nearshore marine areas have been designated as essential for the conservation of UWR steelhead. The Columbia River estuary occurs downstream from the CRS so the effects of the Proposed Action are attenuated as distance increases downstream from Bonneville Dam and large tributary streams influence water quality in the Columbia River. Ongoing implementation of the Columbia River estuary habitat and predator removal or harassment programs are anticipated to have a positive effect on habitat function and predation risk within the estuary. Continued implementation of the habitat program is likely to increase the capacity and quality of habitat in the Columbia River estuary, while improving access to aquatic resources for juvenile salmonids (NMFS 2019). Implementation of the predator removal or harassment programs, which is intended to reduce the consumption of juvenile and adult salmon, will continue to influence the risk of predation on UWR steelhead. Incidental catch of juvenile or adult UWR steelhead during the implementation of predator management programs is considered negligible.

The Proposed Action includes operational modifications to the CRS that may affect water quality downstream from Bonneville Dam. The overall effects of the Proposed Action should maintain current water quality conditions with a slight but potential increase in TDG associated with the flex spill program. The highest TDG levels (125 percent) are expected in the Bonneville Dam tailrace and should decline with increasing distance from Bonneville Dam. The rate of decline is likely related to dilution from tributaries, time of travel, channel morphometry, degassing at the air/water interface, heat exchange, and biological productivity (Schneider and Barko 2006). In juvenile salmon, an increase in TDG will likely manifest in an increased incidence of GBT. Early migrating adult UWR steelhead are likely to be unaffected by the flex spill program; however, late-migrating fish could experience an increased exposure to TDG and GBT. Continued effects on stream temperature, sediment, and turbidity are anticipated downstream from the CRS but are likely to remain unchanged as a result of the Proposed Action. Current passage conditions will be unaffected for juvenile and adult UWR steelhead as they migrate through the Columbia River estuary.

SUMMARY OF BASELINE, CUMULATIVE, AND PROPOSED ACTION EFFECTS

This section summarizes the effects of the Proposed Action on UWR steelhead in the context of existing conditions and cumulative effects. Cumulative effects are effects of future state or private activities that are reasonably certain to occur within the action area. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline condition (whether they are federal, state, or private). To the extent those same activities are reasonably certain to occur in the future (and are state or private), their future effects are included in the cumulative effects analysis.

Most of the effects identified in the analysis above are consistent with effects previously described for management of the CRS in past consultations. In general, the Proposed Action does not result in substantial changes in the identified effects, but there may be some modest site-specific effects.

The summary below follows the general structure of the analysis above and discusses each factor that was previously evaluated.

Operational

Survival

Survival of juvenile UWR steelhead is not affected by passage through the CRS, because they enter the Columbia River downstream of the hydro projects. Juvenile steelhead survival has improved in the estuary due to habitat improvements implemented by the Action Agencies. For adult UWR steelhead, survival has been affected in the estuary up to the Willamette River by pinniped predators.

Future state and private actions, and the effects of climate change and variable ocean conditions have the potential to affect survival of UWR steelhead. Land use activities (primarily private) have the potential to affect juvenile survival by decreasing estuary habitat or degrading abiotic factors, such as temperature. In addition, while harvest is regulated through consultation with NMFS for anadromous fish, state agencies implement fisheries that can have a direct effect on the number of returning steelhead to the UWR tributaries (and in some cases, within the tributaries themselves).

It is anticipated that survival gains that have resulted from previous actions will continue and possibly increase by continuing estuary habitat actions. The continued monitoring of juvenile and adult survival will assist managers in understanding whether survival rates change and inform potential modifications to actions.

Travel Time

Travel time within the tributaries and estuary are not affected by the CRS. Adult travel time is not considered an issue.

It is anticipated that climate change will continue to increase overall temperatures in the Columbia River, and therefore have the potential to further affect adult UWR upstream migrational timing, and possibly juvenile emigration timing.

Continued monitoring of adult UWR steelhead migration to determine travel time and other migrational characteristics will allow managers to determine the success of various actions that are initiated to improve migrational conditions.

Powerhouse passage proportion

Because UWR do not pass through the CRS, this section does not apply to the DPS.

Water quality

Total Dissolved Gas

TDG has increased in the Columbia River since the advent of elevated spill levels for juvenile salmon passage. Past operations increased TDG to very high rates that resulted in GBT in juveniles and adults as they migrated through the CRS. The past levels of GBT led managers to modify operations and spillway structures to reduce levels of TDG, which reduced the occurrence of GBT.

It is anticipated that during spring spill, TDG in the tailraces of CRS dams will range from 120 percent to 125 percent. This flexible spill program may slightly increase the incidence of GBT in juvenile fish. Continued monitoring of juveniles and adults for signs of GBT will inform managers of the effects of this action.

Temperature changes

Water temperatures have been modified as a result of a range of anthropogenic activities, including the existence and on-going operation of the CRS, throughout the Columbia River Basin. Increases in temperature can have a range of effects on both juvenile and adult UWR steelhead.

Ongoing non-federal land management activities that affect temperature, such as agriculture, urbanization, and forestry, are not expected to improve substantially.

Implementation of the Proposed Action will continue to have minimal effects on mainstem temperatures.

Turbidity levels

Currently, sediment loads in tributaries have been affected by historic land use practices and other anthropogenic activities, which results in higher sediment loads that can degrade both spawning and rearing habitat. In the mainstem Columbia River, sediment is retained behind the dams, resulting reduced turbidity and increased predation risk.

In the tributaries, non-federal actions are likely to continue to affect turbidity, but improvements in tributary habitat included in the Proposed Action are expected to result in reduced sediment inputs, resulting in modest, site-specific improvements that will mitigate continued activities that degrade habitat. In the mainstem Columbia River, the current condition is not anticipated to change, and there are no non-federal activities that are anticipated that could affect turbidity levels.

The Proposed Action will continue to improve tributary habitat and will most likely reduce sediment levels in the tributaries upstream of the confluence of the Willamette River with the Columbia River. In the CRS, it is not anticipated that the Proposed Action will change the current condition.

Dam passage (adults)

Because UWR steelhead do not migrate past CRS dams, this section does not apply.

Predation rates

Currently, both juvenile and adult UWR steelhead encounter potential predators in tributaries, the mainstem Columbia River, the estuary, and marine environments. Pinniped predators prey on adults as they enter the Columbia River from the ocean to the Willamette River and upstream to Willamette Falls (and tailrace of Bonneville Dam). A variety of native and non-native fish and birds prey on juveniles as they pass through the CRS, mostly in the tailraces of dams.

Non-federal actions are not anticipated to affect predation rates, except potentially in the tributaries, but the CRS has no effect on predation rates in the tributaries. State regulations determine how some of the non-native fish predators are managed, and these regulations may affect predation rates if a large enough portion of them are removed from the CRS.

The Proposed Action will continue to implement the predator management programs, which should ensure that predation does not worsen, and may reduce overall predation rates.

Non-operational

Predation monitoring

Predation monitoring is implemented primarily to determine the effectiveness of the various predator management programs. Without this monitoring and evaluation, it would not be possible to understand whether the management programs are having the desired effect.

Monitoring predator programs is not anticipated to be affected by any non-federal actions in the future.

The Proposed Action will continue to fund and implement predator monitoring and evaluation programs that have been successful to date in determining the effectiveness of the current management programs, which may harm a small number of individual UWR steelhead

Habitat actions

Currently, habitat conditions in the tributaries, mainstem Columbia River and the estuary have been degraded through land use and other anthropogenic activities. Actions initiated from previous consultations address habitat restoration in tributaries and in the estuary.

Non-federal actions that have the potential to affect UWR steelhead include continued degradation of estuary habitat and projected increased air temperature due to climate change that is warming surface water temperatures.

The Proposed Action will continue to rehabilitate habitat in the estuary.

Fish status and trend monitoring

There are potential effects from CRS-related RM&E programs on UWR steelhead. These effects are associated with the capturing and handling of fish. RM&E activities occur throughout the Columbia River Basin as part of managing the CRS.

There are no non-federal actions anticipated that would affect RM&E activities.

The Proposed Action will continue to implement the RM&E programs that are currently occurring, and these programs could be modified in the future as the results of the monitoring programs are evaluated.

Summary

The effects of the Proposed Action are summarized in Table 3-68, where the effects of the Proposed Action are compared to the current condition and designated as positive (green), no change from the current condition (gray), or yellow, designating an anticipated negative effect. This comparison helps to establish a basis for predicting future effects of the Proposed Action.

All of the actions are expected to either have no effect, or result in a positive effect compared to the current condition (Table 3-68). The Proposed Action managing the CRS does not include tributary habitat improvements in spawning and rearing tributaries where UWR steelhead occur, and as such, all factors within the freshwater spawning and rearing sites are not applicable. Also, UWR steelhead do not migrate through the CRS and therefore, factors associated with the CRS are also not applicable. Factors associated with migration through the estuary for both juvenile and adult UWR steelhead are expected to result in either a positive effect or no change. The anticipated positive effects are the result of estuary habitat improvements and predator control programs.

Table 3-68. Summary comparison of the Proposed Action to current conditions for UWR steelhead salmon by life history stage. Factors color coded green represent anticipated positive effects, gray represents no anticipated change, and yellow represents an anticipated negative effect.

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Freshwater Spawning and Rearing Sites	Survival				Not applicable
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries				Not applicable
	Predation monitoring				Not applicable
	Fish status and trend monitoring				Not applicable
	Juvenile Steelhead Downstream Migration Through the CRS	Survival			
Travel time					Not applicable
Powerhouse passage proportion (juvenile)					Not applicable
TDG levels					Not applicable
Temperature changes					Not applicable
Turbidity levels					Not applicable
Dam passage (adults; includes fallback and overshoot)					Not applicable
Predation rates					Not applicable
Hatcheries					Not applicable
Predation monitoring					Not applicable
Fish status and trend monitoring					Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Juvenile Steelhead Estuary Migration and Rearing, Including the Plume	Survival	x		+	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival
	Travel time	x		=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels	x		=	Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam
	Temperature changes	x		=	
	Turbidity levels	x		=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates	x		+	Continuation of predator management actions are expected to slightly reduce predation rates
	Hatcheries				Not applicable
	Predation monitoring	x		=	
	Fish status and trend monitoring	x		=	
Ocean Rearing	Survival	x	x	=	
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries	x	x	=	
	Predation monitoring				Not applicable

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
	Fish status and trend monitoring				Not applicable
Adult Steelhead Migration to the Willamette River	Survival		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates		x	+	Continuation of predator management actions are expected to decrease predation by pinnipeds
	Hatcheries				Not applicable
	Predation monitoring		x	=	
	Fish status and trend monitoring				Not applicable
Adult Steelhead Migration Through CRS Dams	Survival				Not applicable
	Travel time				Not applicable
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels				Not applicable
	Temperature changes				Not applicable
	Turbidity levels				Not applicable
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates				Not applicable
	Hatcheries				Not applicable
	Predation monitoring				Not applicable
		Fish status and trend monitoring			

Life History Phase	Factor	Juvenile life stage affected	Adult life stage affected	Change from current condition	Comment
Adult Steelhead Migration Upstream of the CRS to the Spawning Areas	Survival		x	=	
	Travel time		x	=	
	Powerhouse passage proportion (juvenile)				Not applicable
	TDG levels		x	=	
	Temperature changes		x	=	
	Turbidity levels		x	=	
	Dam passage (adults; includes fallback and overshoot)				Not applicable
	Predation rates ³⁰		x		Not applicable
	Hatcheries		x	=	
	Predation monitoring				Not applicable
	Fish status and trend monitoring			x	=

³⁰ It should be noted that while not part of the Proposed Action, NOAA and the Action Agencies are exploring options to curtail or reduce pinniped predation at Willamette Falls through other processes.

3.2 NON-SALMONID SPECIES

3.2.1 Southern Distinct Population Segment of Eulachon

The following sections examine the status and factors that have affected the southern DPS of eulachon and the effects of the Proposed Action on this species and its designated critical habitat.

3.2.1.1 Status of the Southern DPS of Eulachon

Eulachon (*Thaleichthys pacificus*) are a small, anadromous forage fish inhabiting the northeastern Pacific Ocean, ranging from northern California northward to south-central Alaska and into the southeastern Bering Sea. Individuals in the southern DPS of eulachon spawn in the lower reaches of coastal rivers from the Nass River in British Columbia to, and including, the Mad River in northern California (Gustafson et al. 2010). The southern DPS of eulachon was listed as threatened under the ESA by NOAA Fisheries on March 18, 2010 (75 FR 13012), reaffirming this conclusion in its 2016 5-year status review (NMFS 2016d). Critical habitat was designated on October 20, 2011 (76 FR 65324) and the final recovery plan published in September 2017 (NMFS 2017e).

There are numerous “populations” of eulachon within the range of the species, with the recovery plan identifying four key subpopulations (Klamath River, Columbia River, Fraser River, and the British Columbia coastal rivers) as a minimum set of “populations” needed to meet delisting criteria (NMFS 2017e). Historically, the largest returns of any spawning population throughout the species' range occurred in the Columbia River. Eulachon return to the Columbia River to spawn between 2–7 years old, with a majority returning at ages three and four. The fish may begin to enter the Columbia River in November to December, and typically reach peak spawner abundance in February. Depending on environmental conditions and subsequent run timing, the presence of adult fish and larvae has been documented in the Columbia River through April and into May.

Eulachon typically spawn in the mainstem Columbia River and usually spawn every year in the Cowlitz River, with inconsistent runs and spawning events occurring in the Gray's, Elochoman, Lewis, Kalama, and Sandy Rivers (Figure 3-28) (Joint Columbia River Management Staff 2010). Spawning in the mainstem Columbia River (as opposed to tributaries) has not been documented above RM 80 (Romano et al. 2002).

Prior to the construction of Bonneville Dam, occasional reports were received of eulachon occurring upstream as far as Hood River, Oregon, and possibly farther (Smith and Saalfeld 1955). Since completion of Bonneville Dam, when returns were high (e.g., 1945, 1953), eulachon have been known to migrate as far upstream as Bonneville Dam (Smith and Saalfeld 1955; Howell et al. 2001), with spawning observed in Tanner Creek on the Oregon side of the Columbia River near the base of Bonneville Dam (OFC 1953) and WDFW/ODFW (2008) in Gustafson et al. (2010) and are suspected of passing through the ship locks, having reached the Klickitat River (Smith and Saalfeld 1955).



Figure 3-28. Map of eulachon in the lower Columbia River and associated tributaries.

Quality data on fishery-independent abundances for eulachon is lacking. Although commercial landings are not applicable for developing annual population estimates because they are influenced by commercial demand, season structure, and environmental conditions, they do provide a useful measure of the relative run strength (Gustafson et al. 2010). Beginning in 1994, substantial declines in commercial landing led to fishery restrictions. Commercial landing increased in 2001–2003 (indicating potential increase in abundance), however that trend reversed with declining returns through the early 2000s (NMFS 2019). According to NMFS, eulachon abundance in monitored rivers has improved substantially in the 2010s, and was relatively high in the 2013–2015 return years, before declining in 2016 and 2017, most likely due to recent poor ocean conditions (NMFS 2019). Low returns are expected in the near term as a result of poor ocean conditions. However, as ocean conditions appear to be improving, which is likely to indicate generally improving conditions for eulachon.

Eulachon are broadcast spawners, and typically prefer spawning areas with coarse-sandy substrate; most adults die after spawning. After fertilization, the eggs settle to the bottom and adhere to river substrates, typically pea-sized gravel and coarse sand (Hart and McHugh 1944). Incubation occurs for about 30–40 days depending on water temperature (Joint Columbia River Management Staff 2010). Young eulachon larvae are about 4.0 to 8.0 mm in length and, are rapidly flushed to the ocean, often within days of hatching, and subsist on their yolk sac during this downstream dispersal (WDFW/ODFW 2001).

Eulachon spend the majority of their life in salt water and little is known about their ecology. Information on the distribution and ecology of juvenile eulachon is scanty due to these fish being too small to be detected in fisheries surveys, and too large to occur in ichthyoplankton surveys (Hay and McCarter 2000). Although it is likely that juvenile eulachon rear in near-shore marine areas at moderate or shallow depth (Barracough 1964) and feed on pelagic plankton, including euphausiids (krill). As they grow at sea, they tend to use waters of greater depths and have been found as deep as 625 meters (Allen and Smith 1988).

Adult eulachon range in size from 14 to 30 cm and are planktivorous in the ocean, but stop feeding when returning to fresh water to spawn (McHugh 1939; Hart and McHugh 1944). The homing instinct of eulachon (returning to birth streams) is not clear, but it is postulated that larvae may spend weeks to months in nearby estuarine environments where they grow significantly in size and may develop the capacity to imprint on large estuaries and eventually home to these areas as adults (McCarter and Hay 1999; Hay and McCarter 2000).

3.2.1.2 Factors Affecting the Status of the Southern Distinct Population Segment of Eulachon

As discussed in the *Federal Register* listing notice (Gustafson et al. 2010), the primary factors resulting in the decline of the southern DPS of eulachon are the destruction, modification, or curtailment of habitat and an inadequacy of existing regulatory mechanisms. The NMFS' Biological Review Team (BRT) identified climate-induced changes in ocean conditions as the most significant threat and climate-induced changes in freshwater habitat as a moderate threat to eulachon throughout the range of the DPS (Gustafson et al. 2010). Other factors identified as low to moderate threats included dams and water diversion projects, dredging, commercial and recreational fisheries, predation or disease, and bycatch of eulachon in other commercial fisheries, depending on when and/or where they occur (Gustafson et al. 2010). While impacts to the ocean and freshwater spawning habitat from climate change are likely to continue into the foreseeable future, bycatch in the pink shrimp fishery is likely reduced in recent years due to the adoption of lights and excluder devices developed specifically to reduce eulachon bycatch (Lomeli et al. 2018).

FRESHWATER SPAWNING AND REARING

Eulachon spawn in the mainstem Columbia River and lower reaches of select tributaries. Habitat conditions in the lower Columbia River and associated spawning tributaries have been influenced by numerous anthropogenic factors, particularly reduced connectivity to floodplain habitat from agricultural, industrial, and urban development. Industrial harbor and port development, and associated dredging of the navigation channel and berthing facilities modifies the river bed, benthic species composition and abundance. Historical chemical contamination in the lower Columbia River may negatively affect embryotic development, growth rates, and egg and larval survival.

The management of the CRS has no influence on the spawning habitats in the lower tributary reaches, but within the mainstem Columbia River, the management of the CRS influences the hydrograph, TDG levels, the sediment transport regime, and in very rare instances, passage of adults attempting to spawn upstream of Bonneville Dam.

Recent increases in spring spill (for juvenile anadromous salmonids) is intended to better resemble historical spring flow conditions, but occurs mostly after eulachon have spawned, thus exposure to effects from increased spill to spawning adults is limited. However, fertilized eggs and juveniles may be exposed to associated elevated TDG levels. Alterations to the natural sediment transport regime likely minimizes habitat forming processes in the lower Columbia River and estuary and reduces turbidity levels during the spring freshet (May and June). Both juvenile and adult eulachon present in those months would experience decreased turbidity, making them more susceptible to visual predators. Though rare (only occurring during periods of exceptionally large return years) adults that attempt to extend their upstream migration past Bonneville Dam are likely delayed or impeded by the structure. Some individuals use the ship locks to pass the dam as velocities in the fish ladder are not conducive to eulachon.

JUVENILE DOWNSTREAM MIGRATION

Spawning above Bonneville Dam is exceptionally rare; however, following those rare instances, juveniles outmigrating are subjected to reduced water velocities in the reservoir, elevated TDG, and uncertain dam passage effects. Once below Bonneville Dam juveniles are typically transported rapidly downstream through the estuary and to the ocean. Once larval eulachon exhaust their yolk sac, individuals forage in the estuary as evidenced by copepod nauplii, phytoplankton, and other micro-organisms identified in stomach content analysis (Gustafson et al. 2010) It is unlikely the operation of the hydropower system has much influence on the distribution or abundance of the micro-organism prey base that larval eulachon use in the estuary in route to the ocean.

Extensive water management activities throughout the Columbia River Basin have modified flow, temperature, and sediment transport regime in the lower Columbia River. It is unclear whether these modifications influence migratory behavior of larval and juvenile eulachon. Reductions in flow may slow downstream migration to some degree. Modified sediment transport likely reduces turbidity and may make juvenile eulachon more susceptible to predation, but the magnitude of this is also unclear and there are no specific estimates available.

OCEAN REARING

Eulachon spend 95-98 percent of their lives at sea (Hay and McCarter 2000), however, little is known regarding the saltwater existence of eulachon. They typically spend 3 to 5 years in the ocean before returning to spawn, although some may spend more time (WDFW/ODFW 2001). At the time of listing, NMFS identified changes in ocean conditions due to climate change as the most important threat to eulachon. The 2010 BRT noted that climate change may result in mismatches between timing of ocean entry of eulachon larvae and availability of crucial prey species; although they have shown an ability to respond positively when ocean conditions are more favorable. 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 (NMFS 2019). Overall, risk to eulachon from climate change effects in

marine environments is high, but there is also a high level of uncertainty regarding the severity of potential impacts; the relative impact to recovery is ranked high (NMFS 2019).

Bycatch in the coastal shrimp fishery was identified by NMFS as a substantial threat to the persistence of eulachon, second only to climate-related impacts. Following recognition that large numbers of eulachon were occurring as bycatch in the pink shrimp fishery (*Pandalus jordani*), efforts have been taken throughout the range of eulachon to reduce this impact. Incidental ocean bycatch of eulachon remains a problem for the species; however recent experimentation with artificial light to illuminate portions of trawl nets in the Oregon ocean shrimp fishery has shown great promise for significantly reducing bycatch of eulachon (NMFS 2017e). Although not a regulatory requirement on ocean shrimp trawl nets, the current efforts are likely to lead to further reductions in bycatch in the future.

ADULT RETURN MIGRATION TO THE SPAWNING AREAS

Entry into spawning rivers appears to be related to water temperature and the occurrences of high tides. Eulachon may enter the Columbia River to spawn beginning as early as November, with spawning activity reported to occur at temperatures from 4 to 10 degrees Celsius; colder temperatures may delay (or even stop) upstream migration (WDFW/ODFW 2001), at least in some rivers. While age determination of eulachon is difficult, adult spawners are variously reported to be 3 to 5 years old (Smith and Saalfeld 1955; WDFW/ODFW 2001) in the Columbia River, with the majority of adult eulachon reported to return at age three, although some are purported to be up to 9 years old (WDFW/ODFW 2001).

Water management throughout the Columbia River Basin has altered natural flow regimes, sediment transport, and water temperatures in the Columbia River mainstem where eulachon migrate and spawn. While water management operations throughout the basin are substantial, it is unknown if these associated alterations in flow, sediment transport or temperature result in impacts to eulachon migration and spawning. Eulachon have been returning to the Columbia River and associated spawning tributaries with modified hydrograph and temperature regime for more than 80 years, yet it is only recently that eulachon abundances declined to the point of ESA-listing. Reductions in sediment transport may make adult eulachon attempting to migrate and spawn within the mainstem Columbia River more susceptible to fish, avian, and pinniped predation, as a result of reduced turbidity; however the magnitude of this impact is generally not considered a substantial overall impact.

Eulachon were once harvested in vast quantities in the Columbia River and associated lower river tributaries, especially the Cowlitz River. Following the listing of eulachon under the ESA, the states of Oregon and Washington have restricted harvest outright in most years, with some limited opportunities for recreational and commercial harvest (e.g., 2014) (NMFS 2019). Incidental harvest from other fisheries (e.g., salmon and steelhead) is extremely unlikely. As a result, NMFS' recovery plan for eulachon lists the level of threat for fisheries in the Columbia River as "low" (NMFS 2017e).

During years of exceptionally large spawning runs, eulachon are known to reach Bonneville Dam. Continued upstream passage for these individuals delayed or otherwise impeded by Bonneville Dam. However, as fish have been observed upstream of Bonneville Dam as far as Hood River, some individuals must be passing, with the ship locks the most likely pathway. However, once past the ship locks, some "fallback" through the dam has been observed. As described in the 2014 and 2019 BiOps, and by the

Pacific States Marine Fisheries Commission (2014), the following numbers of adult eulachon have been observed in downstream passage facilities at Bonneville Dam:

- 1988 – 8,200 adults,
- 2003 – two adults,
- 2005 – five adults, and
- 2014 – 455 adults.

No eulachon have been reported at Bonneville Dam since the 2014 observations. However, applying the hourly sampling rates to the 8,200 adults observed in 1988, NMFS suggests a maximum fallback rate of about 95,500 adults through the bypass system in years when spawning runs are large (NMFS 2019).

3.2.1.3 Status of Critical Habitat

This section describes the status of designated critical habitat and associated physical and biological features (PBFs) of that habitat. In 2011, NMFS designated 16 specific areas in California, Oregon, and Washington as critical habitat for eulachon (76 FR 65324). This includes the lower Columbia River from the mouth to Bonneville Dam and tributaries to the Columbia River in Oregon (Sandy River) and in Washington (Skamokawa Creek, Elochoman River, Cowlitz River, Kalama River, Toutle River, and Lewis River). The physical and biological features of designated critical habitat fall into three major categories (Table 3-69); they are essential to the conservation of eulachon because they support one or more of the species’ life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging) (76 FR 65324).

Table 3-69. Physical and biological features of designated critical habitat for eulachon

Physical and Biological Feature	Components of the PBF
Freshwater spawning and incubation sites	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	Freshwater and estuarine migration corridors associated with spawning and incubation sites that are 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. 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.
Nearshore and marine areas	Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival. Eulachon prey on a wide variety of species, including crustaceans such as copepods and euphausiids (Hay and McCarter 2000; WDFW/ODFW 2001), unidentified malacostracans (Sturdevant 1999), cumaceans (Smith and Saalfeld 1955), mysids, barnacle larvae, and worm larvae (WDFW/ODFW 2001). These features are essential to conservation because they allow juvenile fish to survive, grow, and reach maturity, and they allow adult fish to survive and return to freshwater systems to spawn.

FRESHWATER SPAWNING AND REARING AREAS

Within the mainstem Columbia River, water management activities throughout the basin have resulted in dramatic changes in flow, temperature, and sediment transport regime in areas designated critical habitat for eulachon. Whether these changes influence the conservation value of freshwater spawning and rearing sites for eulachon, however, is difficult to quantify. Eulachon have been successfully spawning and rearing in the mainstem for many years despite changes in flow, temperature, and sediment transport, with only relatively recent declines in the species abundance observed.

In general, spring spill operations occur following peak migration of eulachon, however these operations influence water quality by generating elevated TDG levels in the water where eulachon spawn and hatch. It is possible that increased TDG levels have deleterious impacts on eggs and developing embryos, however, because eggs adhere to sand and gravel substrate on the river bed, depth compensation likely reduces the overall exposure of eggs and developing embryos to elevated TDG, limiting this potential impact.

FRESHWATER AND ESTUARINE MIGRATORY CORRIDOR

Freshwater and estuarine migratory corridors are largely free of obstructions to migration. As described earlier, extensive modifications in flow, temperature and sediment transport regime may influence the conservation value of these habitat for outmigrating larval and juvenile eulachon.

Dredging in the Columbia River for navigation channel and associated berthing areas in adjacent ports and harbors may interact with outmigrating larval and juvenile eulachon, and create a minor obstruction to migration; however, the BRT identified dredging as a very low threat, so it is unlikely that this activity is contributing substantially to the decline of eulachon or the current state of designated critical habitat.

NEARSHORE AND MARINE AREAS

NMFS identified nearshore and offshore marine foraging habitat with sufficient water quality and prey availability to support juvenile and adult eulachon. The length of ocean residency is typically 2-5 years. The conservation value of designated critical habitat is almost exclusively driven by ocean conditions, which is influenced by global factors, such as climate change. Factors such as El Niño, and ocean acidification can have tremendous influence over the habitat conditions that eulachon rely on for survival. These conditions are likely to become more variable in the long term as a result of anticipated climate change. In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO₂ 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). Increased acidification may indirectly affect prey base distribution and abundance throughout the range of eulachon.

3.2.1.4 Species-specific Baseline (without action conditions)

Substantial information on eulachon life history, habitat requirements, species and designated critical habitat status, and known threats can be found in the BRT's status review (Gustafson et al. 2010), the 5-

year status review (NMFS 2016d), and recovery plan (NMFS 2017e) and are hereby incorporated by reference.

3.2.1.5 Proposed action components specific to Eulachon [placeholder pending progress of NEPA]

There are no species-specific actions proposed at this time. A description of the Proposed Action, including non-operational conservation measures that benefit ESA-listed species, is fully described in Chapter 2 of this biological assessment. Eulachon are generally exposed to only a few facets of the Proposed Actions, including the following:

- Columbia River flows as modified by operations of the CRS
- TDG levels modified by operation of the CRS
- upstream passage delays and/or injury at Bonneville Dam (only during years of high returns of adult eulachon)
- downstream passage delay and/or injury (including fallback) at Bonneville dam (only during years of high returns of adult eulachon)
- benefits of habitat enhancement efforts in the Columbia River Estuary
- benefits of avian and predation management

3.2.1.6 Effects of the Action on Eulachon

Within the Action Area, eulachon use the mainstem Columbia River for migration, spawning, incubation, and rearing. Eulachon adults, eggs, and larvae may be exposed to the effects of the Proposed Action from Bonneville Dam, downstream through the estuary to the Columbia River plume. The operation of the CRS may influence freshwater habitat important to eulachon through modification of the Columbia River flows, and changes in water quality parameters, such as river temperature and TDG concentrations during migratory and spawning periods. In addition, Bonneville Dam may restrict passage to upstream spawning areas during times of exceptionally high eulachon abundance. In general, however, eulachon occur primarily downstream from CRS facilities and therefore are not typically directly affected by the facilities themselves.

As stated above, NOAA Fisheries (75 FR 13012) identified destruction, modification or curtailment of habitat and inadequacy of regulatory mechanisms as the principal factors responsible for the decline of the southern DPS of eulachon. Changes in ocean conditions due to climate change remain as the most significant threats to eulachon and their habitats, with climate-induced changes in freshwater habitats identified as a moderate threat (75 FR 13012). However, the remainder of this section addresses areas of potential effect from the operation and maintenance of the CRS.

FRESHWATER SPAWNING AND REARING

Most spawning in the action area occurs in Columbia River tributaries, such as the Cowlitz, Lewis, and Sandy Rivers. Tributary spawning habitat used by eulachon is not affected by CRS operations. Therefore,

only individuals that migrate and spawn in the mainstem Columbia River will be exposed to the effects of the operation and maintenance of the CRS. Spawning is associated with 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. The effects of the Proposed Action are occurring primarily from elevated TDG levels associated with increased spill at CRS run-of-river projects on the lower Snake and Columbia Rivers to support juvenile salmon and steelhead out-migration (approximately April 3 – June 20). Those eulachon exposed to elevated TDG may experience gas bubble trauma, which may result in a range of physiological impacts from minor lesions on the body or gills to, in extreme cases, substantial injury or death.

During periods of high returns, some adults will attempt to pass Bonneville Dam. Operations and upstream passage facilities designed for salmon and steelhead will likely delay/impede upstream migration. Of those individuals that manage to pass upstream, some proportion will fall back through various passage routes, including spillways, juvenile bypass facilities, or turbines, which may result in injury or death.

Following spawning, fertilized eggs drift downstream, adhering to sand and small gravels, hatching in 3–8 weeks depending on water temperatures. Because these eggs and developing embryos are at/near the river bottom, they are not likely exposed to elevated TDG levels generated during spring spill operation.

Operation of the CRS is not likely to influence temperature during the spawning period; therefore, it is not anticipated any temperature effects to adults, eggs, or developing larvae will occur in the mainstem Columbia River.

JUVENILE DOWNSTREAM MIGRATION

Larvae are transported (drift) through the Columbia River Estuary downstream to the ocean and forage on small prey items along the way. While the construction dams throughout the Columbia River Basin, including those associated with the CRS, established a new hydrograph and sediment transport regime in the Columbia River that differs from historic conditions, the Proposed Action will not result in further degradations, and, in fact, is actively operating to more closely mimic historic conditions while ensuring that other authorized purposes, including flood risk management requirements are maintained. Further, modifications to flow and sediment transport have not been identified as influencing migrations travel time or prey abundance in the estuary.

As part of the Proposed Action, the Action Agencies will continue to implement the CEERP to improve estuarine habitat and tidally-influenced portions of tributaries used by eulachon to benefit anadromous salmon and steelhead. The planned improvement in habitat functions expected to provide long-term benefits to native species that use these habitats, including eulachon. In general, no effects to eulachon are anticipated due to estuary habitat improvement project implementation. Appropriate ESA consultation will be undertaken if the Action Agencies conclude that implementation of these projects may affect eulachon. Therefore, outmigrating juvenile eulachon are not expected to be affected by the operations of the CRS during this phase of their life history.

OCEAN REARING

There are no CRS facilities in the Pacific Ocean. The operation and maintenance of the CRS does not influence the survival of eulachon in the Pacific Ocean. Growth and survival of eulachon in the Pacific Ocean is tied to ocean conditions, which in turn are influenced by global processes such as the Northern California Current, Pacific Decadal Oscillation, the North Pacific Gyre Oscillation, the El Niño Southern Oscillation, and climate change. Therefore, eulachon rearing in the Pacific Ocean are not expected to be affected by the operations of the CRS during this phase of their life history.

ADULT RETURN MIGRATION TO THE SPAWNING AREAS

Pacific eulachon return to the Columbia River as early as November and may make multiple exploratory forays into the Columbia River prior to initiating upstream spawning migration. Most returning adults are bound for lower Columbia River tributaries such as the Cowlitz, Lewis, and Sandy Rivers; those that spawn within the mainstem Columbia River may be exposed to elevated TDG during spring spill operations, however this number should be very small as peak spawning occurs in February, well before the spring spill season. Operations of the lower Columbia River dams do not have a substantial impact on flows during the time eulachon adults are returning to spawn. Reduced baseline turbidity levels may increase the susceptibility of eulachon to visual predators during their upstream migration. However, the Action Agencies implement predator management actions to reduce predation on salmon and steelhead. These predation management actions may result in some reductions in eulachon predation, although it is unlikely to be measurable at a population scale.

3.2.1.7 Effects of the Action on Critical Habitat

In 2011, NOAA Fisheries designated 16 specific areas in California, Oregon, and Washington as critical habitat for eulachon (76 FR 65324). The areas include the Lower Columbia River from the mouth to Bonneville Dam and tributaries to the Columbia River in Oregon (Sandy River) and in Washington (Skamokawa Creek, Elochoman River, Cowlitz River, Kalama River, and Lewis River).

Features essential to the conservation of the species, outlined in 76 FR 65324, include (1) freshwater spawning and incubation sites, (2) freshwater and estuarine migration corridors, and (3) nearshore and offshore marine foraging habitat. Feature 3 is not applicable to this analysis. For each of the above features, PBFs essential for conservation of the species were identified in the critical habitat designation. PBFs for feature 1 include flow, water quality, water temperature, and substrate; PBFs for feature 2 include flow, water quality, water temperature, and food. While most of the actual spawning occurs in lower Columbia River tributaries, the mainstem Columbia River still composes a significant portion of critical habitat for the species.

CRITICAL HABITAT – SPAWNING AND REARING

The Columbia River portion of the designated critical habitat (from the river mouth to Bonneville Dam at RM 146.1) accounts for 43.6 percent of the river miles of the total critical habitat designated for eulachon along the Pacific Coast. The CRS has historically been the most important river system for production of eulachon in the southern DPS. Spring spill operations are not likely to substantially modify

the current flow regime, but the PBFs will be affected as a result of increased TDG during spring spill operation. These increases in TDG may diminish the value of spawning and rearing habitat below Bonneville Dam. However, most spawning occurs in the tributaries and/or prior to the implementation of spill operations. No other water quality parameter is anticipated to be influenced by the operation and maintenance of the CRS.

Critical Habitat – Migratory Corridor (Juveniles downstream and Adults upstream)

Migratory habitat will be affected similar to spawning and rearing areas, and mostly will be affected by elevated TDG downstream of Bonneville Dam until it eventually attenuates. However, habitat in the estuary will be enhanced as part of implementing the CEERP. These estuarine habitat enhancement actions will improve overall ecosystem function at the project scale and will likely result in long-term benefits to forage and water quality.

3.2.1.8 Summary of Effects of the Action

NOAA Fisheries identified changes in ocean conditions due to climate change as the most significant threat, and climate-induced changes in freshwater habitat as a moderate threat to eulachon throughout the range of the DPS (75 FR 13012). At a DPS scale, it is very unlikely that the management of the CRS has any measurable effect on the distribution or abundance of the southern DPS of Pacific eulachon.

The operation of the CRS may affect all life stages of eulachon of those individuals present in the Columbia River during spring spill operations because of the effects of exposure to elevated TDG. However, because eulachon typically spawn in tributaries, which are not influenced by TDG produced by Bonneville Dam, this effect is likely negligible.

In the years when adult returns are high, individuals that reach Bonneville Dam are limited in upstream passage, and the ship locks are considered the most likely route available. For the individuals that do manage to pass upstream, some may be entrained back through the dam; those that do “fall back” may experience injury or death depending on the route by which they pass back through the dam.

Any juvenile eulachon originating above Bonneville Dam may also be affected during downstream passage, but given their relatively small size, it is extremely difficult to verify their fate.

Changes in water releases, predator abundance, and actions to improve water quality for listed salmon and steelhead through management of the CRS may provide similar benefits to eulachon. Also, habitat improvement actions in the estuary and lower Columbia River and tributaries are likely to result in overall improvements in ecological and habitat function in these areas. These beneficial effects likely provide some benefits to eulachon as well.

Therefore, based on this analysis, the Action Agencies have determined that implementation of the Proposed Action may affect, but is likely to adversely affect, the southern DPS of Pacific eulachon.

For designated critical habitat, effects on the PBFs of water temperature, substrate, and food were determined above to be likely insignificant while effects on the PBF flow and water quality remain unclear. In particular, it is unclear how increases in TDG will reduce the conservation value of the water quality PBF. In terms of impacts on flow, the existing flow regime has been dramatically modified from historical conditions, and eulachon populations have only relatively recently declined, which indicates

that the flow regime may not be driving these recent changes. However, because of lack of knowledge of relationships between flow, TDG, and different life-history aspects of eulachon, it cannot currently be substantiated as to whether these changes in flow and TDG are adverse to these PBFs.

3.3 FISH AND WILDLIFE SERVICE SPECIES (UPDATES)

3.3.1 Bull Trout

The following sections discuss the status and factors that have affected bull trout (*Salvelinus confluentus*) and the effects of the Proposed Action on this species.

3.3.1.1 Status of Bull Trout

The bull trout was listed as a threatened species in the coterminous United States in 1999. Throughout its range, bull trout are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, incidental angler harvest, entrainment, and introduced non-native species (64 FR 58910 [Nov. 1, 1999]). Since the listing of bull trout, there has been very little change in the general distribution of bull trout in the coterminous United States, and we are not aware that any known, occupied bull trout core areas have been extirpated (USFWS 2015e). However, many of the core areas have observed declines, while a few have maintained or substantially increased their populations.

The 2015 recovery plan for bull trout identifies six recovery units within the listed range of the species (USFWS 2015e). Each of the recovery units is further organized into multiple bull trout core areas, which are mapped as non-overlapping, watershed-based polygons, and each core area includes one or more local populations. Within the coterminous United States, there are 109 occupied core areas that comprise 600 or more local populations of bull trout (USFWS 2015e). Core areas are functionally like bull trout metapopulations, in that bull trout within a core area are much more likely to interact, both spatially and temporally, than are bull trout from separate core areas.

The USFWS has also identified several marine or mainstem riverine habitat areas outside of bull trout core areas that provide FMO habitat that may be shared by bull trout originating from multiple core areas. These shared FMO areas support the viability of bull trout populations by contributing to successful overwintering survival and dispersal among core areas (USFWS 2015e).

To understand the status of bull trout in the Action Area, it is necessary to discuss the bull trout in a broader area, including recovery units, core areas, and critical habitat units. The Proposed Action defines operation and maintenance of the CRS and encompasses a large portion of the Columbia River Basin (Figure 3-29). Bull trout are listed as a DPS within the four-state area of the Action Area. The CRS operates within three of the six bull trout recovery units, including the Columbia Headwaters, Mid-Columbia, and Coastal (Figure 3-29) (USFWS 2015e). Each recovery unit is subdivided into multiple bull trout core areas. Migratory life history forms of bull trout are key to the persistence and genetic diversity of each core area across the range, as well as throughout the Action Area. Within the three recovery units overlapping the Action Area, as many as 91 core areas, four historic areas, and one research needs area are adjacent to or within the bounds of the Action Area. Bull trout in approximately 46 core areas, four historic areas, and one research needs area likely use or have the potential to use habitats within the Action Area in some capacity based on life histories and movement patterns. This represents more than 45 percent of the entire listed entity. Populations of bull trout in this document are discussed in the context of recovery units and core areas.

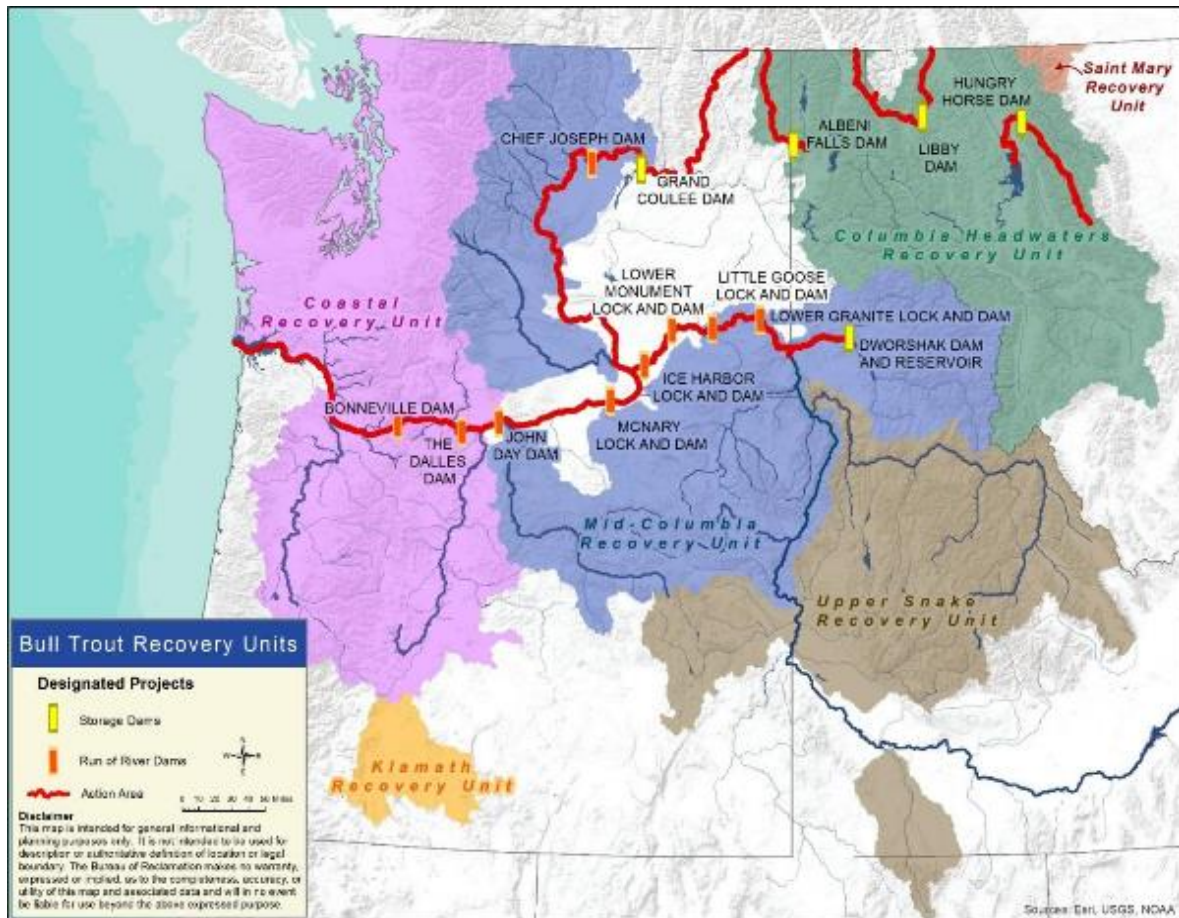


Figure 3-29. Bull trout recovery units in relationship to the CRS Proposed Dam Action and Action Area

3.3.1.2 Factors Affecting the Status of Bull Trout

A range of natural and anthropogenic factors influence the distribution, abundance, and status of bull trout. Within the tributaries that support bull trout spawning and rearing, a variety of natural and anthropogenic factors affect the species and its habitat. Global processes such as climate change have contributed to altered water quality and quantity. Human activities have modified habitat on a broad-scale. These activities include but are not limited to beaver trapping, mining, agriculture, livestock grazing, water diversions, and timber harvest. These activities have degraded water quality, reduced water quantity, decreased riparian function, reduced connectivity with side-channels and floodplains, and reduced habitat diversity (NMFS 2016d; p. 17). Harvest, competition and hybridization with non-native brook trout, competition with lake trout, human-made passage barriers, and angling pressure have also contributed to substantial reductions in the distribution and abundance of bull trout. Also, reservoir drawdowns and subsequent filling have created varial zones (areas demarcated by the range of flows during typical peaking operations) along the shorelines of reservoirs where vegetation is limited due to varying water levels. This lack of vegetation and woody debris limits the establishment of cover.

As the number of anadromous fishes returning to spawn declined, nutrients vital to stream productivity decreased dramatically. Gresh et al. (2000; p. 15) estimated that the transport of marine-derived nitrogen and phosphorus loads has declined to 6 to 7 percent of levels in 1882. These nutrients are

important for salmonid production, and consequently for ecosystem function [(Bisson and Bilby 1998); 389–391; (Naiman et al. 2002); pg. 400]. Over time, these impacts, combined with other factors, reduced habitat carrying capacity in tributaries.

COLUMBIA HEADWATERS RECOVERY UNIT

The Action Area includes bull trout within the Columbia Headwaters Recovery Unit (CHRU) (USFWS 2010, 2015e). The Action Area within the CHRU includes portions of western Montana, northern Idaho, and northeastern Washington. Major drainages include the Clark Fork River Basin, including the Clark Fork River, Lake Pend Oreille, the Pend Oreille River, the Flathead River, Flathead Lake, and the Kootenai River Basin. This recovery unit is a stronghold for bull trout, as many of the headwater tributaries provide cold-water refugia in high-elevation wilderness or protected areas (USFWS 2015d).

There are 35 bull trout core areas within the recovery unit. Fifteen of the 35 are referred to as complex core areas, as they represent large interconnected habitats, each with multiple spawning streams. The 15 complex core areas contain most individual bull trout and the bulk of the designated critical habitat within the CHRU (USFWS 2010). Five of these complex core areas are within the Action Area: Lake Kootenai, Kootenai River, Hungry Horse Reservoir, Flathead Lake, and Lake Pend Oreille (USFWS 2015e). Bull trout from three additional core areas may migrate into the Action Area. The Bull Lake Core Area is located on Keely Creek, a tributary to the Kootenai River. The Swan River Core Area is a tributary to Flathead Lake. The Priest Lake Core Area is located upstream of Priest Lake Dam on the Priest River, a tributary to the Pend Oreille River. Swan River and Priest Lake Core Areas are located above both natural and human-made (Troy and Priest Lake Dams) barriers outside of the Action Area. Each year, very small numbers of bull trout are entrained into the Action Area from these core areas. However, as there is no upstream connectivity to either core area, the Proposed Action would not affect the core area, and this document contains no further discussion of these core areas. Once bull trout leave the Bull Lake and Priest Lake core areas, they become members of core areas within the Action Area and are counted as such.

Bull trout use high-elevation, cold-water tributaries for adult holding, spawning, egg incubation, and juvenile rearing and migration. While some anthropogenic activities have impacted these tributaries, the headwaters are relatively undeveloped and retain many of their original wild attributes and native species complexes. All of the habitat necessary for fulfilling these life stages is located outside of the CRS. Bull trout are not exposed to CRS facilities or operations during adult holding, spawning, egg incubation, and juvenile rearing and migration within the tributary environment. Spawning occurs in the tributaries between September and mid-October in water temperatures between 35°F and 39°F (1.7°C and 3.9°C). Bull trout typically return to the Kootenai River in late October.

Subadult bull trout and post-spawning adult bull trout migrate down the South Fork Flathead River to Hungry Horse Reservoir, where they forage throughout the year. Populations in the Hungry Horse Reservoir Core Area represent a stronghold in the recovery unit due to the stability of yearly redd counts and known harvest rates.

Bull trout entrained over Cabinet Gorge Dam use habitat within Lake Pend Oreille. Since 2001, an average of 35 adult bull trout each year captured below Cabinet Gorge Dam are genetically assigned to tributaries within Montana. The capture efficiency of the trap-and-transport program has been

estimated at 39 percent (GEI 2009), suggesting that a minimum of 90 individuals from LPO-A populations may be present in Lake Pend Oreille and the Action Area at any time. Areas affected by the operation of Hungry Horse Dam, Albeni Falls Dam, and Libby Dam are within the CHRU. Libby Dam does not have fish passage facilities, but migration downstream occurs through the dam via turbine entrainment or during spill events. The water release rate, depth of withdrawal, and seasonal forebay fish density all influence the rate of entrainment through the dam (Skaar et al. 1996). Entrainment studies at Libby Dam using sonar and draft-tube netting documented low numbers of bull trout passing through the dam, primarily in the spring (Skaar et al. 1996). More recently, survival of entrained bull trout has been documented via genetic origin testing, and although no estimate is available for rates of entrainment or survival, more than 50 percent of bull trout captured below Libby Dam for genetic assignment were assigned to the Wigwam River (DeHaan and Adams 2011).

Impoundment of the Kootenai River by Libby Dam in 1972 altered the habitat in the riverine reach downstream of Libby Dam through altered flow patterns, altered river temperatures, and modified sediment transport regimes. These alterations resulted in changes in periphyton, aquatic insects, and fish populations (Dunnigan 2015). Past Libby Dam operations altered water quality parameters and likely significantly impacted bull trout population stability and health throughout the corridor. Past spill events, which elevate TDG levels to up to 135 percent, occurred several times during past dam operations. The events likely altered the behaviors and timing of bull trout movements in the river.

In addition, Lake Kootenai acts as a nutrient sink, retaining approximately 63 percent of total phosphorus and 25 percent of total nitrogen entering the system (Woods and Falter 1982). Consequently, the Idaho portion of the Kootenai River has been considered nutrient-poor (ultra-oligotrophic) and phosphorus-limited. In addition, loss of floodplain connectivity to the entire Kootenai River valley has reduced riparian function and natural nutrient inputs. In the Idaho portion of the Kootenai River, the diminished nutrients have reduced primary productivity over the past two decades (Ross et al. 2015). Another result of the low-nutrient (primarily phosphorus) conditions below the dam has been increased success of the nuisance algae *Didymosphenia geminata* (Didymo) in the Kootenai River below Libby Dam in Montana in the early 2000s. There, it has frequently formed dense mats on the river bottom and may negatively affect bull trout abundance because of reduced abundance of desirable large invertebrate prey (e.g., Ephemeroptera, Plecoptera, and Trichoptera) (Sylvester and Stephens 2011).

Sub-adults and non-spawning adults may be foraging in the Kootenai River year-round. Based on recent genetic studies, the Kootenai River populations directly downstream of Libby Dam are supplemented by entrained bull trout, as most fish collected below the dam originated above it (DeHaan and Adams 2011).

Throughout the year, sub-adults and adults occupy Hungry Horse Reservoir, which provides refugia for bull trout. Downstream movement and entrainment of bull trout through the turbines and spillway probably occur at low levels. However, due to the depth and configuration of penstock withdrawal and the status of populations, the effect of entrainment at the bull trout population level within the core area is low.

Based on an estimated 85 percent survival rate of fish passing through the three non-federal dams in the Clark Fork River (Cabinet Gorge, Thompson Falls, and Noxon) and the survival rates of juvenile bull

trout to adulthood, between 441 and 1,766 juveniles may also be in the Action Area at any point in time. Currently, of these three dams, only Thompson Falls Dam has upstream fish passage; however, construction of a passage facility at Cabinet Gorge Dam is proposed by the Federal Energy Regulatory Commission (FERC).

Albeni Falls Dam blocks passage to bull trout populations that historically exhibited an allacustrine (i.e., move from downstream riverine habitat and spawning areas upstream into a lake to forage and overwinter) life history. Every year, a few bull trout are observed or captured downstream of Albeni Falls Dam during fisheries management and research activities. Genetic samples are collected and all to date have been assigned to populations of bull trout upstream of Albeni Falls Dam (USFWS unpublished data). Impacts from historic operation of Albeni Falls Dam and the lack of passage have limited the survival and life history patterns of the populations downstream. In 2017, the Corps consulted on construction of upstream fish passage at Albeni Falls Dam (USFWS and NMFS 2018). The 2017 BiOp was based on construction of Albeni Falls Dam fish passage by 2022; therefore, this expectation is part of the baseline, and the connectivity barrier will be removed at that time.

Hungry Horse Dam (564 feet high) blocks adult bull trout access to the South Fork Flathead River drainage, which represents approximately 38 percent of spawning and rearing habitat historically available to bull trout in the Flathead Lake system (Zubik and Fraley 1987). The barrier the dam presents to upstream movement of non-native species (e.g., lake trout) is currently considered an asset to bull trout recovery.

Bull trout from populations in the Kootenai River Core Area migrate to spawning areas in tributaries of the Kootenai River between late June and September. Aggregation of substrate at tributary mouths may delay timing or completely block passage of bull trout to spawning grounds, depending on discharge of the Kootenai River and spawning tributaries (Marotz et al. 1988; Sylvester et al. 2016; Dunnigan et al. 2017). Recent data have indicated cause for concern regarding the impact of Libby Dam operations on spawning tributaries above and below the dam, specifically tributary access and passage. Historically, during spring freshets (as high as 60k cfs), flows were high enough to flush substrate accumulation out of Kootenai River tributary mouths. In addition, bull trout had access to preferred foraging habitat upstream of the current Libby Dam site when flows were insufficient to access tributaries. With the construction of Libby Dam, and ongoing operations that flatten flows (rarely above 25k cfs), sediment transport has been reduced, forming large accumulations at tributary mouths that have now hardened. The barrier at Libby Dam also eliminates access to other high quality habitat for bull trout in the Kootenai River and what is now Lake Kocanusa. Within tributaries, upstream land management activities, such as logging, mining, and transportation, have further exacerbated the build-up of sediment at tributary mouths.

Between 2000 and 2016, the states of Montana and Idaho have documented declines of 75 percent or more in bull trout populations in the Kootenai River Core Area. In all cases, access to tributaries during the spawning migration is either hindered or completely blocked due to flows and lengthy accumulated sediment at the tributary mouths. In some cases, the accumulation extends as much as half a mile upstream. One tributary maintains a low, but stable population of bull trout, where a tributary mouth habitat project was implemented in 1999, allowing sediment to be transported out of the creek.

The construction of Albeni Falls, Box Canyon, and Boundary Dams on the Pend Oreille River has fragmented habitat and has negatively affected migratory bull trout (USFWS 2002a). Other dams and diversions without fish-passage facilities in tributaries to Lake Pend Oreille and the Pend Oreille River, including the Cabinet Gorge and Noxon Rapids Dams, further fragmented habitat and reduced connectivity (USFWS 2002b). In addition to eliminating connectivity, dams within the system have significantly altered habitat characteristics in the Pend Oreille River. Operation of each facility continues to have a significant impact on bull trout habitat. Typical spawning, rearing, and overwintering habitats in a free-flowing river with pools, glides, riffles and side-channel habitat have been eliminated. Water temperatures have risen during the summer months and macrophytes and warm-water fish species (including predators of bull trout) have proliferated in this changed environment Northwest Power and Conservation Council (2001); (USFWS 2002b).

MID-COLUMBIA RECOVERY UNIT

The Mid-Columbia Recovery Unit (MCRU) includes portions of central Idaho, eastern Washington, and eastern Oregon (USFWS 2015e, d). Major drainages include the Yakima River, John Day River, Umatilla River, Walla Walla River, Grande Ronde River, Imnaha River, Clearwater River, and smaller drainages along the Snake River and Columbia River. The MCRU encompasses 24 core areas, two historic areas, and one research needs area. The majority of these interact with the Action Area. Bull trout throughout this recovery unit co-existed with salmon, steelhead, and in some areas, lamprey (USFWS 2015d).

The status of bull trout in the MCRU is variable across the unit. Some core areas, such as the Umatilla and Yakima Rivers, contain very small populations. However, other core areas found in the Imnaha, Clearwater, and Wenatchee River Basins are robust. The stronghold populations tend to occur within intact habitat areas, such as wilderness areas and protected forestlands. Throughout the MCRU, consistent primary threats from upland/riparian land management, habitat loss, fish passage barriers, and water quality and quantity exist (USFWS 2015d). Connectivity between core areas of the MCRU is key to the persistence and genetic stability of bull trout.

Above Chief Joseph and Grand Coulee Dams, including Rufus Woods Lake, Lake Roosevelt and their tributaries, very little information exists on the history and status of bull trout populations. The total drainage area above Grand Coulee Dam is 74,100 square miles and includes the Columbia River in Canada and the Kootenai, Pend Oreille/Clark Fork, and Spokane Rivers in the United States. Although suitable spawning habitat exists in several tributaries to Lake Roosevelt and Rufus Woods Lake, no known spawning occurs in the tributaries.

Asotin Creek and the Clearwater River enter the Snake River upstream of Lower Granite Dam within the Action Area. The Tucannon River and the Palouse River enter the Snake River in the lower portion of Lower Monumental Reservoir. Meadow and Deadman creeks are smaller tributaries to Little Goose Reservoir, but do not contain bull trout and are not designated as critical habitat. Spawning and rearing habitats occur in the extreme upper reaches of the major tributaries. In general, subadult bull trout migrate from their respective subbasins to the Snake River during the fall/winter (October to February), and to some extent during the spring/early summer (April to June). Movement from some subbasins to the mainstem has been documented during other months, but this was less common (Barrows et al. 2016b).

The Action Area within the MCRU includes Grand Coulee Dam; Chief Joseph Dam; Snake River dams Lower Granite, Little Goose, Lower Monumental, and Ice Harbor; Dworshak Dam on the North Fork Clearwater River; McNary Dam; and John Day Dam. Construction of Grand Coulee Dam and Chief Joseph Dam did not include fish passage facilities and thus completely blocked upstream passage of salmon, steelhead, bull trout, and other native fish species. Current fish assemblages above both dams contain resident native and non-native species. Entrainment (downstream movement) of both non-native and native fish occurs at both dams, but the degree to which this occurs is unclear.

Operation of the CRS, which includes Chief Joseph and Grand Coulee Dams, altered bull trout habitat and populations. These dams impound the mainstem Columbia River as managed reservoirs. Some of the major impacts include changed flow regimes, barriers to movement, and increased interactions with non-native species (Craig and Wissmar 1993; Rieman and McIntyre 1993).

Bull trout are occasionally observed near the mouths of tributaries in Lake Roosevelt and in the upper mainstem Columbia River. Observation data are sporadic and often anecdotal. Since 2011, reports of bull trout observations in Lake Roosevelt have increased, often in association with high water years. In 2012, observations of 19 bull trout were reported throughout Lake Roosevelt by tribal and educational survey crews, local citizens, and fishing charters (USFWS 2015c). Most of these were assumed to be entrained fish from spawning areas in Canada and the Pend Oreille River. However, genetic assignment to populations has not occurred on any of the bull trout observed. Six bull trout were observed in Sheep Creek that year (Honeycutt 2014). Four additional bull trout were documented in Lake Roosevelt in 2017 (Baker 2015).

In Rufus Woods Lake, bull trout accounted for less than 0.1 percent of the catch during a fish inventory of the lake in 1999 (LeCaire 2000; Beeman et al. 2003). As with Lake Roosevelt bull trout observations, the bull trout likely stem from populations upstream in Canada or the Pend Oreille River Basin. The Colville Confederated Tribes (CTCR) and the NPCC concluded that bull trout use of Rufus Woods Lake was minimal (CTCR 2000).

Between Chief Joseph Dam and the Yakima River, the mainstem Columbia River functions as FMO habitat for bull trout. Bull trout in the reach below Chief Joseph Dam represent fluvial and adfluvial populations that migrate into the Columbia River mainstem from natal tributaries. Sub-adult and adult bull trout are likely present in the mainstem Columbia River during most months. Crews at Chief Joseph Dam collected two adult bull trout from Turbine 2 in January 2016 during turbine dewatering (S. Stonecipher, Chief Joseph Dam, pers. comm.). Additional documentation of bull trout in the Chief Joseph Dam tailrace has occurred sporadically in the past during surveys and recreational fisheries. These fish likely originated from a local core area and migrated upstream into the draft tube.

Downstream of Chief Joseph Dam, bull trout populations face threats from connectivity impairment and reduced access to historic FMO habitat in the mainstem Columbia River. Five non-federal dams (Wells, Rocky Reach, Rock Island, Priest Rapids, and Wanapum Dams) are located downstream of Chief Joseph Dam on the mainstem Columbia River. Each non-federal hydroelectric project has undergone FERC licensing and consultation with the USFWS on operational impacts to bull trout and bull trout critical habitat, including flow and backwater fluctuations at tributary mouths, and they coordinate operation with other dams throughout the CRS. The impacts of their ongoing operation into the foreseeable future are considered in the baseline.

Approximately 73 adult (about 16 per year) bull trout have been counted at Wells Dam. Crews count an average of 176 adult bull trout at Rocky Reach Dam and an average of 93 adult bull trout at Rock Island Dam each year. Radio telemetry and PIT tag information have shown that bull trout from the Methow Core Area have been observed at each of these dams, and adults can migrate downstream through turbines, spill, or smolt bypass systems and return through upstream adult salmon ladders. BioAnalysts (2004); Stevenson et al. (2006, 2007); Stevenson et al. (2008, 2009); and LGL and Douglas PUD (2006) described successful spawning migrations with minimal delay between dams. A total of 408 PIT tagged bull trout have interacted with Wells Dam recently (Douglas County PUD 2014). An average of five adult bull trout are observed in the upstream passage facilities at Priest Rapids and Wanapum Dams annually. While observations of adult and sub-adult bull trout have occurred at all five non-federal dams between Chief Joseph and McNary Dams, there is limited information on which populations they derive from. Therefore, these observations could stem from any population in the Methow, Entiat, Wenatchee, Yakima, and Walla Walla Core Areas.

FMO habitats for bull trout occur in the mainstem Snake River. Upstream movements within the mainstem Snake River corridor were most common during the spring and summer (March to September), and less frequently from October to November. Downstream movements were documented in the mainstem during all months (Barrows et al. 2016b). Downstream passage timing for bull trout includes the time when the juvenile fish bypass systems at the dams are shut down, leaving the turbines and adult fish ladders as the remaining downstream passage routes (Barrows et al. 2016b). Radio-tagged bull trout from middle Columbia River subbasins exhibit a wide range of behaviors, moving upstream, downstream, displaying high fidelity to an area, or showing no discernible pattern to their movements. In addition, sub-adults from middle Columbia River subbasins can spend multiple years using FMO habitat in the mainstem before ascending tributaries to spawn (Barrows et al. 2016b). Bull trout use of the lower Snake River has been documented from observations in the fish ladders, PIT tag detections in the fish ladders and JBSs, through various research projects, through PIT tag detections from bull trout entering the mainstem from tributary subbasins, and through anecdotal accounts (Barrows et al. 2016b). It is likely the numbers below are very low in relation to total numbers of bull trout present in the Snake River.

Adult bull trout from the Imnaha River move into the lower Snake River shortly after spawning and continue into January (Barrows et al. 2016b, p. 103). Approximately 800 to 1,200 adult bull trout return from the lower Snake River to the Imnaha River each year. Radio-telemetry indicates use of the lower Snake River by bull trout from just below the confluence of the two rivers upstream to Hells Canyon Dam. Interactions with mainstem lower Snake River dams are largely unknown, and none have been detected at the PIT detection arrays on any of the four lower Snake River dams (Barrows et al. 2016b). However, from 2006 to 2011, 12 bull trout were collected at the Little Goose Dam juvenile fish facility, and samples were taken for genetic analysis. One of those was determined to be from the Imnaha River.

Incidental entrainment of bull trout through Dworshak Dam has been documented using direct and indirect methods. The Clearwater River Basin Bull Trout Technical Advisory Team (CBBTTAT) (CBBTTAT 1998) concluded that some degree of bull trout entrainment occurs based on entrainment rates documented at other locations, observations of adult migrant bull trout below the dam during spawning migration season, and documented entrainment of kokanee, a preferred prey resource. Subsequent research has demonstrated that entrainment rates for bull trout are low and insignificant at the

population level. Schiff et al. (2005) documented only one bull trout entrained over Dworshak Dam during telemetry studies between 2000 and 2003.

Bull trout exposure to entrainment is primarily a function of proximity to the selector gate intakes and spillways during operation. Available information suggests some level of ongoing risk affecting only a small portion of the bull trout population in Dworshak Reservoir. Schiff and Schreiver (2004) and Schiff et al. (2005) studied migratory behavior in the Dworshak Reservoir and estimated the migratory population size using a combination of mark-recapture and radio-telemetry methods. They determined that most of the migratory bull trout population overwintered in the middle reach of the reservoir several kilometers distant from the dam, but a small percentage of the population stayed near the dam (within 1 kilometer) throughout the winter and spring. These individuals are presumably foraging on kokanee that are also found in deep water near the dam. These individuals are potentially subject to entrainment during drawdown events.

As noted above, construction of Grand Coulee Dam and Chief Joseph Dam completely blocked upstream fish passage, and fish-passage facilities were not constructed. Current fish assemblages above both dams contain resident native and non-native species. A significant loss of range in northeast Washington and Canada, as well as connectivity between core areas throughout the Columbia River Basin, occurred with construction of Chief Joseph and Grand Coulee Dams.

Dworshak Dam is the most significant influence on connectivity within the Clearwater River. Because Dworshak Dam lacks fish passage facilities, bull trout inhabiting the North Fork Clearwater River drainage have been isolated from other core areas in the Clearwater and Snake River Basins, as well as mainstem habitat, since the dam was constructed in 1971.

COASTAL RECOVERY UNIT

The Coastal Recovery Unit in the Action Area includes the mainstem Columbia River downstream of John Day Dam to the Pacific Ocean, including the estuary. Of the 22 core areas and four historic areas in the Coastal Recovery Unit, seven core areas (Lewis River, Klickitat River, Hood River, upper Willamette River, Odell Lake, Clackamas River, and lower Deschutes River) and two historic areas (White Salmon and upper Deschutes Rivers) are in the lower Columbia River Basin adjacent to the Action Area (USFWS 2015d). The Proposed Action would not affect these core areas.

Operations of Bonneville and The Dalles Dams influence habitat and bull trout through this reach. Due to human-made and natural barriers, there is no evidence that bull trout from the Lewis River, upper Willamette River, Odell Lake, and Clackamas River Core Areas enter the Columbia River. If bull trout from these areas enter the Action Area, it is likely at very low numbers. The lower Columbia River provides FMO habitat for bull trout from core areas in the upper end of the unit.

Aquatic habitat in this reach includes the mainstem river, embayments (isolated off-channel ponds), backwaters, and mouths or lower reaches of tributaries and associated seasonally flooded and riparian lands, as well as the Columbia River Estuary (NPCC 2004b). The landscape surrounding Bonneville Reservoir is characterized by steep-forested hillsides and transitions to a broad valley landscape east of The Dalles Dam (Thorson et al. 2003). Vegetation surrounding the western portion of Bonneville Reservoir is dominated by forests of conifers and hardwoods with smaller areas of riparian wetlands. Near Hood River, the vegetation transitions into ponderosa pine forest. The vegetation changes entirely

to grasslands and shrub steppe habitat, with few trees, for the eastern portion of the segment to John Day Reservoir.

Current land uses surrounding Bonneville Reservoir include residential, commercial, and industrial development in urban centers, including Stevenson, Home Valley, Bingen, Washington and Cascade Locks, Hood River, and The Dalles, Oregon. Washington State highway SR 14 parallels the north shore throughout the lower Columbia River reach, and Interstate 84 runs along the south shore. The Burlington Northern Railroad runs parallel to the north shore, and the Union Pacific Railroad runs along the south shore. These transportation corridors are reinforced by riprap revetments along significant lengths of shoreline.

In the rare event that bull trout from the Lewis River, upper Willamette River, Odell Lake, or the Clackamas River Core Areas enter this portion of the Columbia River, they are unable to return to spawning and rearing areas within these core areas due to human-made and natural barriers. However, this portion of the Columbia River provides connectivity between other core areas, including the Hood River, White Salmon River, and Klickitat River. The mainstem Columbia River in these reaches can provide some potential connectivity between these tributary populations, and the connection between these recovery units through the mainstem Columbia River allows expression of fluvial life history and exchange of genetic diversity between recovery units.

3.3.1.3 Status of Critical Habitat

On October 18, 2010, the USFWS issued a final revised critical habitat designation for the bull trout (70 FR 63898). The critical habitat designation includes 32 critical habitat units in six proposed recovery units located throughout the coterminous range of the bull trout in Washington, Oregon, Idaho, Montana, and Nevada. The final recovery plan for bull trout (USFWS 2015e) formally designated these recovery units. Designated bull trout critical habitat is of two primary use types: (1) spawning and rearing, and (2) FMO habitat. The conservation role of bull trout critical habitat is to support viable core area populations (75 FR 63943). Critical habitat units generally encompass one or more core areas and may include FMO areas, outside of core areas, that are important to the survival and recovery of bull trout.

The final rule excludes some critical habitat segments. Critical habitat does not include (1) waters adjacent to non-federal lands covered by legally operative incidental take permits for Habitat Conservation Plans (HCPs) issued under the Act, in which bull trout is a covered species on or before the publication of this final rule; (2) waters within or adjacent to Tribal lands subject to certain commitments to conserve bull trout or a conservation program that provides aquatic resource protection and restoration through collaborative efforts, and where the Tribes indicated that inclusion would impair their relationship with the Service; or (3) waters where impacts to national security have been identified (75 FR 63898).

Bull trout have more specific habitat requirements than most other salmonids (USFWS 2010b). The predominant habitat components influencing their distribution and abundance include water temperature, cover, channel form and stability, spawning and rearing substrate conditions, and migratory corridors. The PCE (primary constituent elements)/PBFs (physical or biological features) of bull trout critical habitat, as revised in 2010, are (USFWS 2010b):

1. Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
2. Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.
5. Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
6. In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
7. A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
8. Sufficient water quality and quantity, such that normal reproduction, growth, and survival are not inhibited.
9. Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Action Area and nearly all 14 project facilities fall within bounds of designated critical habitat for the bull trout.

COLUMBIA HEADWATERS RECOVERY UNIT

Critical habitat in the CHRU and located within the Action Area includes two CHUs. The upper basin areas related to Libby Dam fall within the Kootenai River CHU 30 (Figure 3-30), while the areas around Hungry Horse Dam and Albeni Falls Dam fall within the Clark Fork River Basin CHU 31 (Figure 3-31).

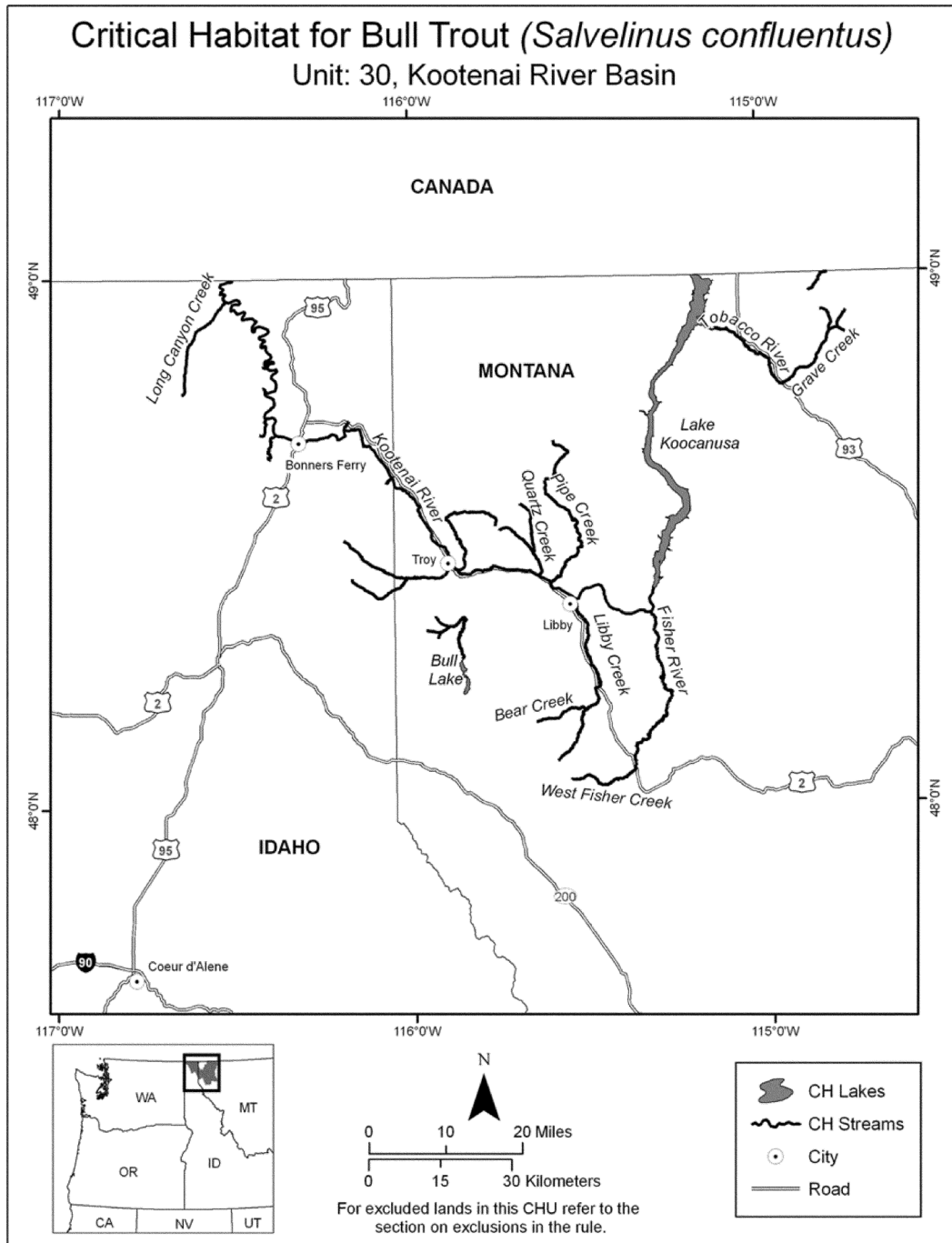


Figure 3-30. Critical Habitat Unit 30, Kootenai River Basin (USFWS 2010b)

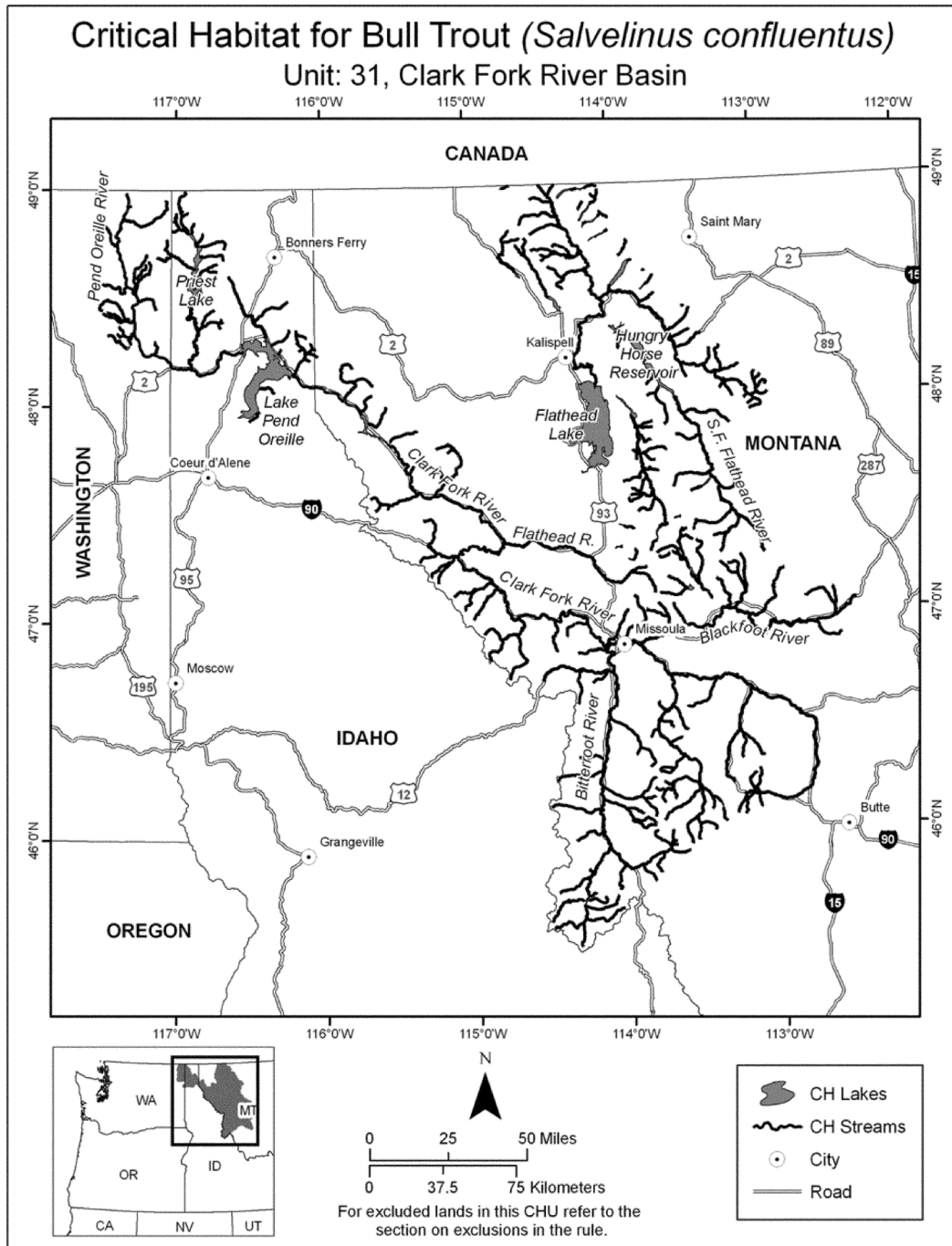


Figure 3-31. Critical Habitat Unit 31, Clark Fork River Basin (USFWS 2010b)

The Lake Kootenasa CHSU provides some of the most secure and stable bull trout refugia across the range and may provide a very important stronghold against potential extinction (USFWS 2010b). While the Lake Kootenasa sub-unit is strong and resilient and supports large populations of adfluvial bull trout, hydropower dam construction and operation significantly altered the Kootenai River CHSU. The construction of Libby Dam in 1974 effectively severed populations in the Kootenai River from productive spawning habitat in Grave Creek, Wigwam River, and other river systems in Canada. Reduced nutrients,

productivity, and large woody debris, fragmented connectivity, tributary delta aggregation, changes in peak and base flows, occasional gas bubble trauma, and altered thermal regimes associated with dam operation have reduced function and quality of critical habitat in the sub-unit. USFWS identified the Kootenai River CHSU as essential to bull trout conservation because it conserves a relatively rare big-river fluvial life history form in the CHRU and produces some of the largest fluvial individuals within the range of the species (USFWS 2010).

USFWS identified the South Fork Flathead (above Hungry Horse Dam) critical habitat sub-unit as essential for bull trout conservation, as it is one of the most stable refugia for bull trout throughout the coterminous range (USFWS 2010b). Most of the spawning and rearing habitat in this CHSU is protected and unaltered habitat within the Bob Marshall Wilderness.

The Lake Pend Oreille critical habitat sub-unit includes the lower Clark Fork River below Cabinet Gorge Dam, Lake Pend Oreille, lower Pend Oreille River below Albeni Falls Dam, and their tributaries. The value of secure and stable refugia, as well as the predominantly adfluvial life history, justified the sub-unit as essential for the recovery of bull trout. Re-establishing broadly distributed local populations throughout the sub-unit was necessary for recovery within this sub-unit (USFWS 2010b). The unique life history of allacustrine (spawning downstream of lake habitat) adfluvial bull trout further supports the necessity of the sub-unit for recovery.

The information below describes the PBFs for bull trout critical habitat and addresses whether each PBF is present in the CHRU.

PBF 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

The Kootenai River CHU 30 is not properly functioning for PBF 1 due to the lack of floodplain connectivity caused by diking adjacent to the Kootenai River and Libby Dam operations. Within Clark Fork River CHU 31, PBF 1 is present and contributes to FMO habitat in Hungry Horse Reservoir due to thermal stratification and the Flathead River due to floodplain connectivity. Below Albeni Falls and Box Canyon Dams, cold-water habitat is limited, but some patches persist in tributaries. Overall, across CHU 31, cold-water refugia is properly functioning in the reservoirs and tributary sub-units.

PBF 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

Within Kootenai River CHU 30, although migration habitat is functional in the Lake Kocanusa sub-unit, the overall status of migration habitat in the Action Area is not properly functioning. Migration barriers from Libby Dam, bedload deposition at tributary mouths, as well as seasonal temperature barriers have resulted in altered connectivity between local populations and delayed spawning. Migratory habitat within the Clark Fork River CHU 31 is not properly functioning within the Action Area due to the presence of dams.

PBF 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Within the Action Area portion of the Kootenai River CHU 30, abundant food resources are functioning at-risk; there is abundant of forage in Lake Koocanusa, but the Kootnai River downstream of Libby Dam is nutrient- and resource-limited. Across the Clark Fork River CHU 31 within the Action Area, abundant forage is not considered limiting, and this PBF is properly functioning. Large populations of native and non-native forage are present throughout the unit.

PBF 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Within the Kootenai River CHU 30, habitat complexity is considered functioning at-risk due to areas of available cover and complexity but reduced floodplain function and wood recruitment in the mainstem river. Across the Action Area in the Clark Fork River CHU 31, habitat complexity is limited by dam operation, woody debris recruitment, and shoreline development. Therefore, this PBF is considered functioning at-risk.

PBF 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Within the Action Area, temperatures appear to be within normal ranges in the Kootenai River CHU as a result of selective withdrawal capabilities at Libby Dam. Preferred temperatures are variable across the Clark Fork River CHU and within the Action Area. Lake habitats such as Flathead Lake, Hungry Horse Reservoir, and Lake Pend Oreille are properly functioning for temperature. However, the mainstem Clark Fork and Pend Oreille Rivers have significantly elevated summer temperatures. Therefore, this PBF is functioning at-risk within the Action Area.

PBF 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

Bull trout do not spawn within the Action Area, so PBF 6 is not applicable.

PBF 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

This PBF is considered not functioning in the Kootenai River CHU. Libby Dam operations for flood risk management, hydropower, and recreation have fundamentally altered the annual hydrograph above and below the dam, with lower spring flows, somewhat higher summer and fall flows, and higher winter flows compared to the pre-dam hydrograph. Bull trout habitat in the mainstem Kootenai River downstream of Libby Dam has been negatively affected by altered in-stream flow patterns (USFWS 2015b). Because of the lack of flushing flows in the mainstem and legacy tributary perturbations, substrate at the mouths of Kootenai River tributaries are aggrading and seasonally may block passage (Paragamian et al. 2010). Across the entire Clark Fork River CHU, dams have altered the natural hydrograph. Therefore, within the Action Area, this PBF is considered not properly functioning.

PBF 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Within the Action Area, PBF 8 in the Kootenai River CHU is considered functioning at-risk. Bull trout critical habitat in the mainstem Kootenai River downstream of Libby Dam is negatively affected by reduced flushing flows, low nutrients, and recent *Didymo* blooms (USFWS 2015b). Water quality is impacted across the entire Clark Fork River CHU because of historic mining and land use, dam operations, and elevated temperatures. Therefore, this PBF is considered not properly functioning within the Action Area.

PBF 9: Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Based on the presence of non-native competitive and predatory species, as well as hybridizing species throughout the Kootenai River CHU and little indication of impacts to populations, especially in the Lake Koochanusa sub-unit, this PBF is functioning at-risk. Northern pike, brook trout, and lake trout represent significant threats across the Clark Fork River CHU and are present in many sub-units. Based on the presence of non-native competitive and predatory species, as well as hybridizing species throughout the entire Clark Fork River CHU within the Action Area, this PBF is considered not properly functioning.

MID-COLUMBIA RECOVERY UNIT

Within the MCRU, three critical habitat units fall within the bounds of the Action Area (USFWS 2010a, b). The mainstem upper Columbia River CHU 22 includes the Columbia River from John Day Dam upstream to Chief Joseph Dam. The Mainstem Snake River CHU 23 includes the Snake River from Hells Canyon Dam downstream to the confluence with the Columbia River. Lastly, the Clearwater River CHU 21 includes all portions of the Clearwater River Basin to its confluence with the Snake River.

The Clearwater River CHU (Unit 21) consists of 2,702.1 km (1,679.0 miles) of streams, as well as portions of some lakes and reservoirs. In 2010, the Clearwater River CHU was determined essential for bull trout to maintain distribution in a unique area of the MCRU (USFWS 2010). The mainstem upper Columbia River CHU 22 includes the mainstem Columbia River from Chief Joseph Dam downstream to John Day Dam and all inundated/backwater portions of tributaries (USFWS 2010). This CHU was identified as essential for conserving migratory corridors for fluvial bull trout habitat in adjacent core areas (USFWS 2010). The entirety of the mainstem upper Columbia River CHU 22 falls within the Action Area. The mainstem lower Snake River CHU 23 falls completely within the Action Area. The mainstem lower Snake River CHU is essential for migratory life history expression, facilitating genetic exchange, and ensuring connectivity between core areas along the Snake River.

The Columbia River upstream of Chief Joseph Dam, including Rufus Woods Lake and Lake Roosevelt above Grand Coulee Dam, are not designated critical habitat. However, changes in water quality from elevated TDG, temperature, and other factors, as well as flow conditions upstream, influence PBFs within designated critical habitat downstream. While bull trout spawning and rearing do not occur within CHU 22, bull trout use the unit for FMO year-round. The mainstem upper Columbia River (CHU 22) provides connectivity between many core habitats and is likely impaired due to the presence of nine dams, as well as temperature and habitat constraints. In addition to dam construction and operation, the mainstem lower Snake River has been altered by reduced habitat complexity, little to no natural

floodplain connectivity due to levees and bank armoring, and from agricultural practices alongside the river. Bull trout are known to occupy and use the Mainstem Snake River throughout the year for foraging and overwintering.

The information below describes the PBFs for bull trout critical habitat and addresses whether each PBF is present in the MCRU.

PBF 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

Within the Clearwater CHU 21 portion of the Action Area, PBF 1 is functioning at-risk because of impacts from transportation corridors, channel straightening, and reservoir operations. Within the mainstem upper Columbia River CHU 22 and mainstem Snake River CHU 23 portions of the Action Area, PBF 1 is not properly functioning due to lost wetlands and floodplain connectivity from dam operations and shoreline development.

PBF 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

Downstream of Dworshak Dam, there are no known barriers in the Mainstem Clearwater River, and migration between core areas is possible. The Clearwater River CHU is functioning at-risk within the Action Area for migration as a result of Dworshak Dam. Passage and migration corridors throughout the mainstem upper Columbia River CHU 22 are insufficient for bull trout due to lack of passage at Chief Joseph and Grand Coulee Dams and operations at other dams, so PBF 2 is considered functioning at-risk for this CHU. The Mainstem Snake River CHU 23 is considered functioning at-risk for PBF 2 due to likely fish passage delays and mortality risks at the dams.

PBF 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Clearwater CHU 21 is rated as functioning at-risk for PBF 3 based on reduced native salmon forage and riparian function below Dworshak Dam. Mainstem upper Columbia River CHU 22 and mainstem Snake River CHU 23 are rated as functioning at-risk for PBF 3 based on reduced native salmon forage and riparian function throughout the Action Area.

PBF 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Habitat complexity downstream of Dworshak Dam has been reduced by dam operations, and complexity in tributaries above Dworshak Dam has been reduced by timber management and roads, so PBF 4 is functioning at-risk in the Clearwater CHU 21 portion of the Action Area. Habitat complexity in the Mainstem Upper Columbia and Mainstem Snake River CHUs is not properly functioning due to simplified habitat created by dams, their impoundments, and their operations and development adjacent to the rivers.

PBF 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Water temperatures in the Clearwater River CHU are functioning at-risk within the Action Area due to elevated summer temperatures in tributaries, portions of Dworshak Reservoir, and the Clearwater River. In the designation of critical habitat, PBF 5 was identified as not present in the Mainstem Columbia and Snake Rivers due to the existence of the dams and elevated temperatures. While not identified as a PBF in the mainstem upper Columbia River and mainstem Snake River CHUs, temperatures in the Columbia River influence distribution, migration, and foraging opportunities for bull trout throughout the Action Area and between core areas. Seasonally, elevated temperatures in passage facilities and in the river impede movement of bull trout, specifically non-spawning adults and sub-adults.

PBF 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

Spawning and rearing habitat is not present within the Clearwater, Mainstem Upper Columbia, and Mainstem Snake River CHUs portions of the Action Area.

PBF 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PBF 7 in the Clearwater CHU is rated functioning at-risk due to altered flows and hydrograph from operating Dworshak Dam. Numerous dams alter the flow regime and hydrograph of critical habitat within the mainstem upper Columbia River CHU, so this PBF is not properly functioning in the Action Area. Operations of four dams on the Snake River, as well as upstream dams in the Snake and Clearwater River Basins, alter the flow regime and hydrograph throughout the Mainstem Snake River CHU, resulting in a rating of not properly functioning for this PBF.

PBF 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

PBF 8 is rated functioning at-risk for the portion of the Clearwater CHU within the Action Area due to water quality impacts associated with releases from Dworshak Dam, in-stream suction dredging associated with placer mining, and nutrient imbalance in Dworshak Reservoir. PBF 8 is rated as not properly functioning for the Mainstem Upper Columbia CHU due to elevated TDG resulting from dam releases. The Mainstem Snake River CHU in the Action Area is rated as not properly functioning due to elevated temperatures and TDG.

PBF 9: Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

PBF 9 is not properly functioning for Clearwater CHU 21 because of the presence of brook trout populations throughout the Action Area. In addition, this PBF is not properly functioning for the mainstem upper Columbia River and mainstem Snake River CHUs due to numerous non-native species found in the Columbia and Snake Rivers.

COASTAL RECOVERY UNIT

USFWS identified habitat in the lower Columbia River as FMO for bull trout, and it is included in the mainstem lower Columbia River CHU 8 (USFWS 2010). Within this reach, CHU 8 includes the free-flowing reaches of the Columbia River up to ordinary high-water mark elevations. It was determined that the lower Columbia River CHU provides essential FMO habitat for extant tributary populations of bull trout in the Lewis, Hood, Klickitat, and Deschutes Rivers and connectivity between these core areas, as well as facilitating the potential reestablishment of a population within the White Salmon River. Numerous anthropogenic stressors have led to significant habitat modification in the lower Columbia River. In lower portions of this reach, navigation channel development and maintenance, as well as diking, draining, and filling of estuarine wetlands and off-channel habitats, are the primary stressors.

The information below describes the PBFs for bull trout critical habitat and addresses whether each PBF is present in the Coastal Recovery Unit.

PBF 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

In the mainstem, PBF 1 is present but provides a limited contribution to FMO habitat. The existence of dams, levees, dikes, and shipping channels has significantly altered the timing and magnitude of hydrologic events and significantly reduced overbank flows and connections between the river and its floodplain (NMFS 2011a). The inundation of wetlands from the construction of Bonneville and The Dalles Dams has resulted in the drying and loss of many wetland and riparian habitats (NPCC 2004b). Shoreline development for transportation corridors has further reduced the interaction between the mainstem river and shoreline springs. Based on lost floodplain connectivity, reduced overbank connection, and inundation of wetlands and riparian areas, this PBF is considered not properly functioning in the Action Area.

PBF 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

Historically, the lower Columbia River region is believed to have largely supported the fluvial life history form of bull trout; however, dams built within several bull trout core areas have isolated or fragmented watersheds, causing bull trout to now adopt the adfluvial life history form (USFWS 2015a). From 2006 to 2014, a total of three bull trout have been observed in the fish ladder at Bonneville Dam, and none have been observed at The Dalles and John Day Dams (Barrows et al. 2016b). Since passage facilities at The Dalles and Bonneville Dams were designed for anadromous salmon and steelhead, it is likely they are insufficient for bull trout. Therefore, this PBF is functioning at risk in the Action Area.

PBF 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The mainstem Columbia River provides productive foraging habitats for migratory bull trout, and an abundant food source exists throughout the year in this reach (USFWS 2015a). Forage fish within this reach include juvenile salmon and steelhead, whitefish, sculpins, suckers, and minnows (USFWS 2010). The large numbers of hatchery-raised salmon and steelhead released into the CRS annually provide an

abundant source of prey for bull trout. Some species, such as salmon and steelhead, also compete with bull trout for prey. This PBF is considered properly functioning.

PBF 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

The historic operation of the dams, dredging of the navigation channel throughout the Columbia River, and significant development have altered recruitment of large wood, habitat complexity, off-channel areas, and other environments of this PBF. Therefore, this PBF is not properly functioning.

PBF 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

PBF 5 was identified as not present in the mainstem Columbia River when critical habitat was designated due to the existence of dams and elevated temperatures. While not identified as a PBF in the CHU, water temperatures in the area influence bull trout use and are seasonally limiting.

PBF 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

Spawning and rearing do not occur within this CHU, so this PBF is not present.

PBF 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

Within the mainstem upper Columbia River, numerous dams alter the flow regime and hydrograph of critical habitat. Therefore, this PBF is not properly functioning in the Action Area.

PBF 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Based on the water quality impairments from elevated TDG, temperature, and agricultural and industrial runoff, this PBF is not properly functioning within the Action Area.

PBF 9: Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

This PBF is not properly functioning within the Action Area due to the large numbers of non-native species.

3.3.1.4 Effects of the Proposed Action on Bull Trout

This section addresses the effects of the Proposed Action on bull trout and designated critical habitat, and is organized by USFWS Recovery Units, then by river reaches associated with each project, and lastly by Core Area. The key effects of the CRS differ between the storage projects in the upper basin and the run-of-river projects in the middle Columbia and lower Columbia reaches. Storage projects in the upper

basin affect passage, drive mainstem flows, and in some cases, influence temperature and TDG supersaturation. The run-of-river projects slow mainstem water velocity, create TDG, and have fish passage facilities and operations, but have minimal ability to influence river flow, temperature, and turbidity beyond current conditions that are a result of the existence and operation of dams and other anthropogenic modifications throughout the Columbia River Basin.

COLUMBIA HEADWATERS RECOVERY UNIT

The Proposed Action affects the following core areas within the CHRU: Hungry Horse, Flathead Lake, Kootenai River, Lake Pend Oreille, Priest Lake, and Lake Kootenai.

Libby Dam Reach

Effects on the Species

Libby Dam Operations and Maintenance

Important operational relationships affecting bull trout habitat in this basin include reservoir elevations in Lake Kootenai and the impact of these elevations on reservoir productivity, how reservoir temperatures influence discharge temperatures, and how discharges from Libby Dam affect downstream habitat inundation. Higher reservoir elevations in the warm summer months result in a thicker water layer in which primary production and zooplankton production (i.e., euphotic zone) occurs in Lake Kootenai. High reservoir elevations during winter (which have a large quantity of cold water) reduce the ability to provide warm/normative discharge temperature during spring and early summer in the Kootenai River. Bull trout forage in the reservoir and in the river relies on this production for food the following winter. Lake productivity under the current operations would continue to positively affect bull trout growth and/or survival in Lake Kootenai (Marotz et al. 1996, 1999), but lower flows and colder temperatures in spring and summer would likely suppress primary and secondary production in the river downstream of Libby Dam.

Under the Proposed Action, Lake Kootenai would be above elevation 2,450 feet for 7 more days on average (15 percent) than current operations during the summer when productivity is critical. The expected result would be slightly higher productivity and increased food web.

The minimum elevation of Lake Kootenai each year influences insect larvae production the following year. The minimum elevation of the reservoir is typically in mid-April. The higher this minimum elevation, the greater the insect larvae production and the more food available for juvenile bull trout (Chisholm et al. 1989; Marotz et al. 1996, 1999). Under the current operation, the average minimum reservoir elevation would be 2366 feet MSL during median years. The maximum elevation of Lake Kootenai is related to volume and surface area and to the proximity of the reservoir surface to terrestrial insect deposition, a food source for bull trout. The reservoir typically reaches maximum elevation in early August (Marotz et al. 1996; Sylvester et al. 2019). Under the current operation, the median maximum reservoir elevation would be 2453.1 feet, which is 95.4 percent of full pool.

The average minimum annual pool elevation of Lake Kootenai under the Proposed Action would be approximately 2 feet lower in dry and average years than under the current operations. The expected

result would be more frequent annual dewatering and decreased benthic insect production, which may result in a decrease in bull trout growth and/or survival. The annual maximum elevation of Lake Kootenai under the Proposed Action would be higher, as shown by the 1.6 ft higher median July 31st elevation than under the current operations, and may result in slightly higher terrestrial insect deposition under this alternative.

Water temperature in Lake Kootenai influences bull trout habitat suitability in the reservoir, and reservoir surface elevation and volume influence the thermal structure of the pool. Reservoir temperature (Dunnigan, unpublished) is determined by several variables, the most indicative of which are volume of the reservoir through the winter (as measured by minimum pool elevation in April), inflow, and air temperature. Fish seek preferred temperatures, and the volume and temperature range influence the amount of preferred habitat. For bull trout, optimal growth occurs at 13.2°C, while the upper lethal temperature for bull trout is 20.9°C (Selong et al. 2001). Under the current operations, the mean monthly reservoir temperature in the months of January through August (analysis was not performed for the September through December period) would range from 3.5°C in March to 11.3°C in August. Water temperature in Lake Kootenai under the Proposed Action would not be substantially different from that under the current operations.

Discharge from Libby Dam affects habitat for bull trout in the Kootenai River below the dam. Maximum high flows greater than or equal to 20 kcfs are needed seasonally during the spring freshet period of May 15 through June 15 to flush and sort fine sediments and gravels. Under the NAA, Libby Dam would provide discharge of 20 kcfs or greater for 11 to 16 days (25th to 75th percentile) during the spring freshet. The mean flow rate would be 18.2 to 20.8 kcfs, with a peak discharge of 23.1 to 26.9 kcfs. This would support seasonal flow objectives for flushing and sorting sediments and gravels. However, these higher flows are insufficient to reshape tributary deltas that can prevent bull trout access during the fall (low river flow) spawning season (Marotz et al. 1996; Hauer et al. 2016).

Under the Proposed Action, Libby Dam would provide discharge of 20 kcfs or greater for 12 days, on average, during the spring freshet, which is one day less than mean for the current operations. The mean flow rate from May 15 to June 15 under the Proposed Action would be slightly less than under the current operation, and would be insufficient to mobilize or reshape tributary deltas that can prevent bull trout access during low flows in the fall spawning season (see Kootenai River Mitigation Actions below where this issue is addressed).

Food availability for bull trout and off-channel inundation and connectivity would be optimized with discharges of 9 to 12 kcfs from Libby Dam during the minimum flow requirement period for bull trout of May 15 through September 30 (Marotz et al. 1996; Hoffman et al. 2002; USFWS 2006). The current operations would provide a median discharge of 10.7 to 15.1 kcfs during this period; therefore, the current operations and the Proposed Action would support varial zone and off-channel inundation and productivity objectives for bull trout. While MO1 would have somewhat lower discharges from Libby Dam than the current operations, these reduced flows would provide slightly more usable habitat.

Operations at Libby Dam have been adjusted to improve downstream habitat conditions for sturgeon while remaining consistent with VARQ FRM procedures. The calculated spring water releases are meant to provide appropriate water velocities, temperature, and depths in sturgeon spawning areas. Bull trout occur in areas affected by these releases both upstream and downstream of Libby Dam. These measures

are meant to improve habitat and replicate more normative river characteristics. Adult and juvenile bull trout in the downstream reaches affected by increased spring sturgeon flows will likely continue to benefit from improvements to habitat quality. Sturgeon flows will not affect bull trout spawning areas, which are located in tributaries of the Kootenai River outside of the Action Area. Neither the augmentation flows for sturgeon nor the subsequent augmentation flows for salmon will negatively affect bull trout habitat in the Kootenai River downstream of Libby Dam, as the flows will be above the minimum flows required for bull trout (6,000 + cfs May 15 through September).

Reduction of summer draft helps in shaping a steady, gradually declining hydrograph to protect bull trout and other resident fish downstream of the dam in the Kootenai River. Previous summer double-peak operations have resulted in a period of reduced flow between sturgeon operations and salmon flow augmentation. During this period, the varial zone established after the sturgeon operation became productive; when flows increased for salmon, the newly inundated varial zone remained unproductive for an extended period until productivity was re-established. When productive, the varial zone provides a source of prey (e.g., macroinvertebrates) for resident fish, such as bull trout. A smooth progression from sturgeon flows to salmon flows and end-of-summer flow reductions will help ensure against this dewatering.

Further, ramping rates, daily shaping, and minimum flows will continue and are intended to maintain the productive habitat of the varial zone while minimizing the likelihood of stranding fish that come to forage and get trapped as flows are reduced. Limits to the flow augmentation draft minimize non-normative summer river flows while ensuring a smooth, gradually declining hydrograph to protect fish from stranding. Bull trout are highly mobile, and the gradually declining hydrograph is expected to give foraging bull trout the opportunity to migrate to deeper water and avoid stranding. Maintenance of minimum flows for bull trout May 15 through September will also help protect them and their food organisms from dewatering and overall habitat loss in the river.

Water temperatures will continue to be managed via selective withdrawal gates during non-isothermic periods and are likely to continue to be appropriate for both juvenile and adult bull trout. Cool release temperatures that are not controlled by the selective withdrawal gates after the reservoir de-stratifies in the late fall and before it re-stratifies in the spring are appropriate for both juvenile and adult bull trout.

If spillway discharge occurs during the spring months, the increased velocity downstream will not negatively affect bull trout, as it will not influence spawning areas (which occur outside of the Action Area) nor occur at a time of year when juveniles are susceptible to scouring. Entrainment of bull trout through Libby Dam does occur, but based on the relative abundance in the Kootenai core area, it does not appear that management agencies in Montana consider entrainment to be a limiting factor for bull trout upstream of the dam; entrainment studies performed by Montana FWP in the early 1990s only documented 6 entrained bull trout over 2½ years of study. Survival of entrained fish (sub-adults and adults alike) may artificially increase abundance of bull trout in the Kootenai core area downstream of the dam, and evidence of this does exist; adult bull trout Floy-tagged in British Columbia were/are periodically re-captured in spawning tributaries downstream of Libby Dam, and genetic and isotope information from the local population in the downstream reach below Libby Dam indicates that roughly half of the population originates from natal tributaries upstream of the dam. In addition, the use of the spillways increases TDG saturations downstream, with higher TDG levels when the sluiceways must be used for spill. Symptoms in fish from elevated TDG can include formation of gas bubbles in blood and

other tissues (termed gas bubble trauma, or GBT), possibly blocking blood flow or causing other injury with potential for infection. Prolonged high TDG levels are lethal to bull trout and other organisms bull trout rely on as a food source. Avoidance of areas with elevated TDG or recuperation is possible if the fish are deeper than the compensation depth, below which the likelihood of bubble formation is minimized, although fish do not volitionally select depth related to gas concentration.

Bull trout could be affected following maintenance activities at the dam. Each of the five generating units requires a 30-day outage each year for preventive maintenance. Units are taken offline one at a time, and the draft tubes are partially dewatered for internal access. At no time are fish handled during the dewatering process, as the draft tubes are never fully drained. However, at the conclusion of the outage, the draft tube stop logs are removed, which allows fish access to the tailrace. If an outage becomes prolonged (more than a few days), fish may be removed from the dewatered draft tube by hand (in coolers) and released into the river. This handling could cause stress or mortality to bull trout if they are captured, transported, and released.

The Action Agencies continue to make operational adjustments based on best available scientific information. These actions likely benefit bull trout by 1) maintaining inundation of productive varial zones, and 2) by providing normative thermal conditions during spring through fall via implementation of minimum bull trout flows and management of discharge temperature. Areas of high TDG could result in short-term negative effects on bull trout immediately downstream of the dam, and extended periods can lead to serious injury, stress, and death. The handling of fish during maintenance activities could result in direct short-term stress or mortality, resulting in take of bull trout. Overall, however, any adverse effects from Libby Dam operations and maintenance on either the Kootenai River Core Area or Lake Koocanusa Core Area bull trout populations, or on bull trout critical habitat, are likely to be minimal. Rather, implementation of the Proposed Action will maintain suitable habitat conditions for bull trout in the Action Area.

Kootenai River Non-operational Conservation Measures

As part of the Proposed Action, Bonneville will provide funding and/or technical assistance to support implementation of a variety of activities to benefit sturgeon and bull trout, such as habitat improvements, conservation aquaculture, and nutrient additions. Bull trout should also benefit from sturgeon habitat improvements, as discussed below.

Habitat Improvements

Kootenai River White Sturgeon habitat improvement projects have been identified through 2025 (see Section 2.5.2), which subsequently would enhance mainstem habitats used by bull trout. These projects could include floodplain enhancement, wetland restoration, tributary access and restoration, substrate enhancement, and development of riparian vegetation. It is expected that implementation of these habitat improvement projects will increase primary productivity, which will benefit bull trout within the Kootenai River Core Area. Unlike sturgeon, bull trout spawn in tributaries of the Kootenai River rather than in the mainstem. Therefore, habitat improvements for sturgeon in the mainstem may be beneficial to adult and subadult bull trout that use the area for FMO.

Bull trout in the Kootenai River below Libby Dam have been blocked from spawning and rearing habitats located along the Kootenai River due to long standing operations impacting flow and sediment movement at the mouths of tributaries (see section 3.3.1.2). In 2021, Bonneville will contribute funding for an initial assessment of blocked passage to bull trout key spawning tributaries identified by USFWS, followed by up to two upstream passage improvement projects over the period of 2021–2026.

Protecting and enhancing bull trout aquatic habitat, notably spawning and rearing tributaries, has been identified as the most effective way to maintain or restore bull trout populations (NRCS 2006). Kootenai River bull trout access to these spawning and rearing tributaries would greatly benefit local population numbers and long-term survival of the species by reestablishing access to cold water and loose, clean gravel, and to areas of upwelling, such as cold-water springs or subsurface flows. The addition of log jams and woody debris at the mouths of these tributaries would provide instream cover for bull trout and channel complexity for stream processes, such as pool formation and sediment deposition.

All projects will complete the required environmental compliance and permitting processes prior to implementation, thereby considering and reducing impacts to bull trout to the extent possible. Some habitat restoration actions will align with bull trout PCEs (e.g., cover or shelter, space for individual and population growth and for normal behavior) and could indirectly benefit the Kootenai River Core Area population.

The habitat restoration projects do not include habitat actions within the Lake Koocanusa Core Area for bull trout and, therefore, will not impact bull trout in either the reservoir or the tributaries upstream of Libby Dam.

Conservation Aquaculture

The conservation aquaculture program has previously been funded and exists in the baseline. Ongoing funding will ensure that the sturgeon population will be supplemented by capturing mature sturgeon and spawning them under controlled conditions to produce progeny for later release. The capture of wild sturgeon for the program could result in incidental capture of bull trout from the Kootenai River Core Area population, as bull trout may be harmed when captured in gill nets, set lines, or by angling gear used for collecting sturgeon broodstock. Even if immediately released, the stress of handling could also result in bull trout mortality. IDFG has reported that one to three bull trout are caught annually during the sturgeon collection operations (USFWS 2006).

Nutrient Addition

Bonneville has supported nutrient supplementation programs in the South Arm of Kootenay Lake and Kootenai River since 2004 and 2005, respectively. Under the Proposed Action, nutrient enhancement of the South Arm of Kootenay Lake will continue into the near future (at least 5 years) and will be shaped by Monitoring and Evaluation (M&E) results. These efforts will continue to enhance food web productivity and benefit native fish populations in the lake, including bull trout from the Kootenai River Core Area population. Under the Proposed Action, the Kootenai River nutrient enhancement program will also continue, and results will be monitored as part of research and M&E. Given past results, it will be expected that continuation of these programs will lead to continued increased productivity, which will benefit bull trout adults and sub-adults foraging, migrating, and overwintering in the Kootenai River

Core Area within the Action Area. No nutrient additions are proposed upstream of Libby Dam in Lake Kooconusa. Nutrient additions in the downstream areas will not affect bull trout in the Lake Kooconusa Core Area because the dam will prevent nutrients from transferring upstream via the movement of organisms.

Research and Monitoring and Evaluation

M&E funded by Bonneville will monitor and assess the effects of project implementation and evaluate the effectiveness of new actions on sturgeon, with opportunistic monitoring for effects to bull trout and other fish species. Some projects underway for M&E include sampling and handling of fish, which could result in incidental injury or mortality of bull trout, as discussed above. Continuation of the M&E program will be primarily aimed at increasing the sturgeon knowledge base and refining management measures. The program will also result in the accumulation of beneficial information on habitat in the Action Area that could also be applied to bull trout management. Therefore, M&E actions will benefit bull trout in the Kootenai River Core Area with minimal adverse effects. Lake Kooconusa bull trout will not be monitored by the M&E program specifically, because the focus of the program is sturgeon and bull trout that occur below Libby Dam in Idaho. The Action Agencies will evaluate effects to Lake Kooconusa bull trout only if new information reveals that the operations at Libby Dam are affecting bull trout in a manner or to an extent not previously considered.

Effects on Critical Habitat

Operations of Libby Dam under the Proposed Action will be consistent with sturgeon recommendations for providing flows for critical habitat attributes, including water depth, velocity, and temperature in the lower Kootenai River in Idaho. In addition, Libby Dam flows are managed to support salmon and bull trout during late summer and early fall. FMO critical habitat for bull trout in the Kootenai River Core Area will likely be improved by flow management for sturgeon, resulting in long-term beneficial effects.

The critical habitat designation for bull trout was revised in 2010 and now includes Lake Kooconusa. Bull trout critical habitat upstream of Libby Dam is expected to remain steady, as compared to baseline conditions.

The effects of the Proposed Action on each PCE³¹ for bull trout critical habitat (shown in bold below) are discussed as follows:

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

The Proposed Action will have no effect on this PCE in Lake Kooconusa. The lake will continue to provide cold FMO habitat with thermal refugia for bull trout.

³¹ Note that PCEs have been replaced by the term *physical and biological features*, or PBFs, under the new regulatory definition of destruction or adverse modification of critical habitat (81 Fed. Reg. 7214, Feb. 11, 2016). In order to maintain consistency between this BA and prior documents in the consultation history, and because the change in terminology does not change the analysis, the PCE terminology is retained in this document.

The Proposed Action will have no effect on this PCE in the mainstem of the Kootenai River below Libby Dam. Dam operations will not alter groundwater resources.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action will have no effect on this PCE in Lake Kooconusa, and the lake will continue to provide FMO habitat and connection to high quality spawning and rearing habitat for bull trout in the Lake Kooconusa Core Area. Migration into the Tobacco River is not affected by reservoir drawdown.

The Proposed Action will have no effect on this PCE below the dam and will include the continuation of VARQ FRM procedures, ramping rates, and bull trout minimum flows so that bull trout are not physically stranded or blocked due to flow operations. The dam will remain a physical barrier to upstream and downstream migration. While the Proposed Action will not result in a change in potential barriers due to sediment build up at tributary confluences, ongoing operations will not eliminate the barrier either.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

Limiting summertime draft in Lake Kooconusa will incrementally improve recruitment of food organisms in the reservoir, as terrestrial vegetation would be closer to the reservoir margins (only when the reservoir is full can this be fully realized). The minor increase in prey from terrestrial sources may benefit younger bull trout that do not yet forage on fish species and larger bull trout that forage on fish that may consume terrestrially derived organisms.

Under the Proposed Action, an abundant seasonal supply of entrained kokanee and other species will continue to supplement the diets of bull trout in the Kootenai River immediately downstream of Libby Dam. In addition, Libby Dam operations have been adaptively managed to reduce impacts to varial zone productivity. Proposed habitat restoration actions, such as those aiming to increase primary production or habitat complexity in sturgeon spawning reaches, will also have a positive effect by encouraging the development of a more complex food chain.

Trapping of nutrients in Lake Kooconusa has altered nutrient availability downstream so as to reduce primary and food web productivity. Nutrient additions under the Proposed Action will help offset this.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

The Proposed Action will have no effect on this PCE in Lake Kooconusa, and the lake will continue to provide FMO habitat for bull trout. Reservoir habitat complexity is unlikely to be altered by limiting the extent of summer or winter drafts.

The Proposed Action will include habitat restoration actions in the sturgeon spawning reaches that will improve bull trout FMO habitat quality in the Kootenai River downstream of Libby Dam. Restoration activities designed to improve floodplain connectivity and increase the complexity of the river with the

addition of large woody debris and other features will provide cover or shelter for adult and subadult bull trout. PCE 4 is affected by high and variable winter flows in the Kootenai River as a result of changing habitat stability (Muhlfeld et al. 2003).

PCE 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.

The Proposed Action will have no effect on this PCE in Lake Koocanusa.

The Proposed Action will continue to manage water temperatures in the Kootenai River to benefit sturgeon. Under the current operation, May through June water temperature goals have been achieved for almost all days. These temperatures are protective of adult and subadult bull trout as well as sturgeon and will continue under the Proposed Action. Otherwise, established temperature release targets will address needs of bull trout in the river during the rest of the year.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.

This PCE is not applicable because bull trout spawning occurs in tributaries of the Kootenai River outside of the Action Area.

PCE 7: A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

This PCE does not apply to Lake Koocanusa.

Continuation of the Proposed Action is expected to have a neutral or positive effect on this PCE, although conditions are altered during the high and variable winter flows. The hydrograph of the Kootenai River is significantly altered from its historical state due to the existence and ongoing operation and maintenance of Libby Dam, combined with downstream land and water uses that have changed the hydrograph. Libby Dam is currently being operated to follow VARQ FRM procedures, as well as tiered volume-based sturgeon augmentation flows, salmon augmentation flows, and bull trout minimum flows, all of which mimic a more normative river hydrography. Continuation of these actions is expected to have a neutral or positive effect on this bull trout PCE. However, PCE 7 is altered during high and variable winter flows in the Kootenai River.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The Proposed Action will have no effect on this PCE in Lake Koocanusa as compared to the current action.

Kootenai River hydrography downstream of Libby Dam has been permanently altered by the existence and ongoing operation and maintenance of the Libby Dam, diking, land use alterations, and water consumption. Libby Dam will continue to be operated to follow VARQ FRM procedures, which include tiered sturgeon augmentation flows and minimum bull trout flows, to facilitate growth and survival of bull trout in the Action Area. Spill may pose some risk through the elevation of TDG saturation, especially in spring. Elevated TDG saturation may result in a temporary water quality impediment. Nutrients trapped in Lake Kootenai have altered water quality downstream so as to reduce primary and food web productivity. Nutrient additions will continue to help offset the nutrient trapping, and this PCE should remain similar to baseline conditions.

PCE 9: Sufficiently low levels of occurrence of non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Proposed Action will have no effect in Lake Kootenai or the Kootenai River that unduly favors nonnative species that may prey on, compete with, or interbreed with bull trout.

Hungry Horse Reach

Effects on the Species

The Hungry Horse core area of bull trout is one of the most robust and least threatened core areas. Implementation of the Proposed Action would include the continuation of previous operational benefits designed to increase reservoir productivity and improve habitat conditions. The primary threats to the Flathead Lake core area are introduced species and angling pressure, which are not affected by the Proposed Action. The core area population is stable, and efforts to manage non-native species are ongoing and managed by the Confederated Salish and Kootenai Tribes (unrelated to the FCRPS).

Although bull trout in Hungry Horse Reservoir could potentially be affected by entrainment, this has not been documented under the baseline operating regime, suggesting that entrainment is not a biologically significant concern. The current action generally maintains these operational conditions, indicating that the action is not likely to have any measurable effect on bull trout entrainment rates relative to the environmental baseline. Therefore, the current action is likely to maintain the species-level abundance and productivity indicators for bull trout in Hungry Horse Reservoir.

A move toward a more normative flow regime began with the 1995 NMFS FCRPS BiOp, and was further refined by the 2000 USFWS BiOp. Improvements to the operating regime restored the hydrograph to a semblance of pre-dam conditions in terms of the frequency and timing of seasonal peak- and low-flow conditions, with higher-than-natural winter flow rates. Muhlfeld et al. (2011) used an Instream Flow Incremental Methodology model to evaluate the effect of flow regime changes in the Flathead River on habitat area and suitability for bull trout and other native fish species. They specifically considered the effect of various flow conditions associated with recent FCRPS management regimes. While the South Fork Flathead was not addressed in this study, the findings are nonetheless relevant because the hydrographic effects considered are similar in timing and larger in magnitude compared to the study reaches in the mainstem Flathead River. They found that the 2001 to 2008 operational regime provided the best approximation of pre-dam habitat conditions and productivity while meeting other system

requirements. They also found that the baseline ramping rates established in the 2000 FCRPS BiOp produced significant habitat benefits by smoothing river flows and reducing varial zone impacts.

Effects on Critical Habitat

The following sections describe the effects of the Proposed Action on each PCE for bull trout critical habitat.

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

In general, reservoir operations have the potential to affect hyporheic exchange along river reaches by changing groundwater residence time (Reclamation 2011). Under baseline conditions, the South Fork Flathead River hyporheic flows have been impaired by development, and the Flathead River is connected to a shallow alluvial aquifer. Areas with high groundwater influence provide overwintering habitat for bull trout in the Flathead River Basin.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action would have no effect on this PCE. The reservoir, South Fork Flathead, and Flathead River would continue to provide FMO habitat and connection to high-quality spawning and rearing habitat for bull trout. Hungry Horse Dam would remain a physical barrier to upstream and downstream migration, as a continuation of the baseline condition. Reservoir operations implemented in 2009 to reduce water level fluctuation during the summer and fall would continue to reduce habitat fragmentation along migratory corridors.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The Proposed Action would continue operations that have improved PCE 3 in the Hungry Horse Reach. Changes in reservoir operations that reduced deep power drafts have increased the consistency of water levels during primary vegetation growth periods, improving habitat conditions for terrestrial organisms that rely on riparian vegetation. The improved consistency of water elevations also benefits aquatic macroinvertebrates.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

The Proposed Action would have minor, insignificant effects on PCE 4 during seasonal reservoir drawdowns. In Hungry Horse Reservoir, the water depth, thermal stratification, and shallow shoreline habitat provide the most significant habitat complexity and contribution to FMO habitat. The South Fork Flathead River provides deep pools that serve as refugia, and the lower Flathead River provides deep runs with cobble and boulder substrate, as well as pools with large wood. Continued operations under

the Proposed Action would continue to maintain these areas of FMO habitat. PCE 4 may be affected by minimum flows that are slightly higher than the natural condition.

PCE 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

The Proposed Action would have insignificant effects on PCE 5 in the Hungry Horse Reach. The Hungry Horse core area is one of three that is projected to contain significant cold-water refugia for bull trout with respect to climate change. The South Fork Flathead River below Hungry Horse Dam contains water temperatures suitable for all ages of bull trout, contributing to FMO habitat in this reach. The Proposed Action would continue operations that are contributing to FMO habitat and cold-water refugia for bull trout. Furthermore, following the installation of the selective withdrawal system at Hungry Horse Reservoir in 1995, temperatures have more closely approximated pre-dam temperatures, and PCE 5 is likely to continue to contribute substantially to FMO habitat.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

The Proposed Action would have insignificant effects on PCE 6 in the Hungry Horse Reach. PCE 6 is not present in Hungry Horse Reservoir, but high-quality spawning and rearing habitat is present in the tributaries upstream of the reservoir. The South Fork Flathead River below the dam and the mainstem Flathead River primarily serve as FMO habitat, with spawning and rearing habitat in the tributaries. The Proposed Action would continue to maintain this FMO habitat for bull trout.

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

The Proposed Action would have insignificant effects on PCE 7 in the Hungry Horse Reach. PCE 7 addresses the timing and amount of streamflow, a characteristic that is, by definition, not present in a reservoir environment. Downstream of Hungry Horse, habitat conditions for bull trout have improved following Reclamation's implementation of more natural flow regimes under VARQ (Muhlfeld et al. 2011). The baseline condition of altered peak flows would not be further reduced under the Proposed Action, and the improved habitat conditions under VARQ would be expected to continue. PCE 7 may be affected by minimum flows that are slightly higher than the natural condition

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The Proposed Action would have insignificant effects on PCE 8 in the Hungry Horse Reach. Operational changes implemented in the 1990s and under the 2000 FCRPS BiOp improved water quality conditions in this reach, and these improved water quality conditions would be expected to be maintained under the Proposed Action. The Action Agencies will continue to operate Hungry Horse Dam under VARQ and the FCRPS BiOp.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Proposed Action would have negligible effects on PCE 9 at Flathead Lake and upstream of Hungry Horse Dam. Hungry Horse Dam would continue to provide a barrier to lake trout or other non-native species. Below the dam, PCE 9 would continue to be impaired by the presence of northern pike and lake trout, but continuation of current operations under the Proposed Action would not affect the level of these species. Efforts to control these species, ongoing under the baseline, would continue to occur separate from the Proposed Action.

Albeni Falls Reach

The Albeni Falls Dam (AFD) Reach consists of two segments—Lake Pend Oreille and the Pend Oreille River downstream of Albeni Falls Dam. It is located in CHU 31 and the CHRU lower Clark Fork geographic region.

Effects on the Species

Implementation of the Proposed Action would include the continuation of previous operational benefits designed to increase reservoir productivity and improve habitat conditions. The primary threats to the Lake Pend Oreille core area are upland/riparian land management and instream flow, instream impacts from transportation corridors, nonnative predators/competitors (lake trout, brook trout, northern pike) and water temperature. These threats would not be appreciably changed by implementation of the Proposed Action. The core area population is stable. The potential for direct impacts on bull trout compared to the environmental baseline is limited to entrainment and lack of upstream fish passage.

The Proposed Action generally maintains the baseline discharge conditions at Albeni Falls Dam established in the 2000 FCRPS BiOp, with the addition of flexible winter power operations (FWPO). Genetic analysis of individuals captured downstream of the dam has determined that the majority of individuals studied originated from spawning populations upstream from Albeni Falls Dam, including tributaries to Lake Pend Oreille, the Priest River tributary to Pend Oreille River, and the Clark Fork below Cabinet Gorge Dam (DeHaan et al. 2005; DeHaan and Ardren 2007). Thus, entrainment is occurring, with more than 25 bull trout recovered and released above Albeni Falls Dam (B. Bellgraph, PNNL, pers. comm. 2015). However, recent estimates of abundance and population structure of bull trout in the Lake Pend Oreille system indicate the population has remained stable and is near or above the recovery goal of 2,500 adults dispersed across six populations, with at least 100 adult spawners (Meyer et al. 2014). Based on this information, bull trout entrainment rates are probably small. As a continuation of the baseline condition, some bull trout may be entrained downstream through Albeni Falls Dam. This could result in direct and indirect mortality and stress. Direct and latent mortality was evaluated by Normandeau and Associates (Normandeau 2014) at Albeni Falls Dam using two different sizes of rainbow trout as surrogates for sub-adult and adult bull trout. Normandeau's results showed a relatively high survival rate of sub-adult (99.4 percent) and adult trout (97.6 percent) that passed through a spillway bay and a high survival rate for sub-adults (99.5 percent) and adults (90.1 percent) that passed through a turbine. In addition to the potential for mortality and injury, bull trout that pass downstream through Albeni Falls Dam are unable to migrate back upstream past the dam, as there are no upstream passage facilities. Authorization for fish passage has been approved at AFD, a corresponding feasibility study is complete, and the Corps is currently waiting for funding for final design and construction.

Effects on Critical Habitat

The following sections describe the effects of the Proposed Action on each PCE for bull trout critical habitat (shown in bold).

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

The Proposed Action would have discountable effects on PCE 1 in the Albeni Falls Reach. Springs, seeps, groundwater sources, and subsurface water connectivity do not play a large role in water quality or water quantity in Lake Pend Oreille. In Lake Pend Oreille, thermal stratification is typically the primary mechanism providing thermal refugia for bull trout (Fraley and Shepard 1989). Albeni Falls Dam operations may influence shallow groundwater exchange, but the influence of this exchange would not be of sufficient scale to influence thermal refugia in the lake as a whole.

Downstream of Albeni Falls Dam, cold-water habitat is limited, but some patches persist in tributaries (e.g., LeClerc Creek and Indian Creek (Box Canyon pool), Sullivan Creek (Boundary Pool), and others) (USFWS 2002c). An inventory of these and other cold-water areas has been completed as part with restoration actions to begin in 2020 as part of MOA actions with the Kalispel Tribe (J. Conner, Kalispel, pers. comm. 2019), and via FERC relicensing required for Boundary and Box Canyon Dams. Although climate change may continue to limit available cold-water habitat, the Proposed Action would not reduce the amount of thermal refugia available.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action would have no effect on this PCE. Lake Pend Oreille would continue to provide FMO habitat and connection to high-quality spawning and rearing habitat for bull trout. If fish pass downstream of Albeni Falls Dam, they cannot regain access to the upper river or lake. Bonneville currently funds temporary fish passage at AFD via electrofishing efforts below the dam, implemented by Kalispel Tribe and Eastern Washington University. The Kalispell temporary trap installed below AFD has not collected bull trout since installation in 2014. Upon completion and operation, bull trout downstream of Box Canyon Dam can be passed upstream, where they would reach the base of Albeni Falls Dam. Selective upstream passage could be provided by the Kalispel Tribe with a temporary Denil trap and upstream transport. A feasibility study for permanent fish passage at Albeni Falls Dam was completed in 2018 and is in the review phase for funding for design and construction. Until that is completed and implemented, Albeni Falls Dam will remain a physical barrier to upstream migration, as a continuation of the baseline condition, and bull trout that remain downstream of Albeni Falls dam will be disconnected from the Lake Pend Oreille and Priest River systems.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The Proposed Action would have a discountable effect on PCE 3 in the Albeni Falls Reach. During summer operations (between June/early July and early to mid-September), the lake elevation is maintained between 2062 and 2062.5 feet. Under these conditions, bull trout would continue to benefit

from the riparian input of terrestrial organisms, as well as forage fish and kokanee prey based on primary production in the lake. The kokanee population has increased substantially in recent years (IDFG 2016), and the Proposed Action would not be expected to affect the population trend. Therefore, the food base for bull trout is likely to remain abundant.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

The Proposed Action would have insignificant effects on PCE 4. In Lake Pend Oreille, habitat complexity consists of water depth, thermal stratification, and shallow shoreline habitat. PCE 4 is impaired in the Pend Oreille River downstream of Albeni Falls Dam due to historic land management practices. The river between Albeni Falls and Box Canyon dams consists mainly of shallow, slow-moving water, numerous sloughs, and backwater areas. The Proposed Action includes continuing current operations and would not significantly increase or decrease habitat complexity in this reach.

PCE 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

The Proposed Action would have discountable effects on PCE 5 in the Albeni Falls Reach. Because the dam drafts from a relatively shallow portion of the impoundment, the ability of the dam to influence downstream temperature conditions is limited. Temperatures in the main body of the lake range from 36°F to 72.5°F, and in the nearshore areas range from 36°F to 79.7°F (Tetra Tech 2002). Surface water temperatures in Lake Pend Oreille and the Pend Oreille River first exceed 19°C by the end of June, 22°C by mid-July, and reach maximum temperatures in excess of 24°C at the end of July and in early August (Corps unpublished data). Although this exceeds the range of suitable temperatures, cooler temperatures persist during lake stratification in the summer. Water temperatures in mainstem FMO habitat (including the lower Pend Oreille River and run-of-the river reservoirs) and the lower reaches of most tributaries are marginally high for bull trout survival in the summer and may continue to increase with projected increases in air temperature due to climate change (USFWS 2015b). Potential water temperature increases would not be a result of project operations relative to the environmental baseline.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

PCE 6 is not present. The action area for the Albeni Falls Reach does not include spawning or rearing areas.

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

The Proposed Action would have insignificant effects on PCE 7 in the Albeni Falls Reach. The Proposed Action includes continuing operations.

Lake Pend Oreille is refilled to 2062 feet in mid- to late June, depending on flood risk, forecasts, and snowpack conditions in the Pend Oreille River Basin. The lake is maintained in a summer operating range of 2062 to 2062.5 feet from June until mid- to late September. The lake elevation is reduced to 2060 feet by September 30, and to 2051 feet by November 15. The pool is generally held within a half-foot of this elevation through December, depending on hydrologic conditions. Under FWPO, there is the potential for greater fluctuation of Albeni Falls Dam discharge and the elevation of Lake Pend Oreille during the winter period (December 15 to March 31).

PCE 7 is not present in Lake Pend Oreille and provides a limited contribution to FMO habitat below Albeni Falls Dam. Although the hydrograph varies from the natural hydrograph, continuing operations would not further reduce availability of bull trout habitat relative to the hydrograph in Lake Pend Oreille.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The Proposed Action would have insignificant effects on PCE 8 in the Albeni Falls Reach, including Lake Pend Oreille and the Pend Oreille River.

Water quality considerations related to temperature are discussed above under PCE 5. Other components of water quality would be consistent with the environmental baseline condition. The Proposed Action includes continuing operations.

High TDG levels will continue to occur during the spring freshet, although reductions may occur with upstream dam modifications (e.g., Cabinet Gorge), consistent with environmental baseline condition. TDG increases under FWPO are expected to be minor (USACE and BPA 2011).

Albeni Falls Dam can spill up to 10 kcfs using all ten spillway gates, and using a uniform spill pattern, without increasing downstream TDG saturation levels. Although spill can increase under FWPO, increases in TDG would be expected to be less than 5 percent (USACE and BPA 2011). Continuing current operations would not degrade water quality conditions compared to the environmental baseline.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Proposed Action would have insignificant effects on PCE 9 in the Albeni Falls Reach. Lake trout are common and represent the singular primary threat to bull trout in the FMO habitat in Lake Pend Oreille (USFWS 2015b). Northern pike are of considerable concern in the river downstream of Albeni Falls, and hybridization of bull trout and brook trout can occur in tributary streams. PCE 9 would continue to be impaired by the presence of lake trout and northern pike, among other species, but continuation of current operations under the Proposed Action would not affect the levels of these species. Efforts to control these species, ongoing under the baseline, would continue to occur separate from the Proposed Action.

MID-COLUMBIA RECOVERY UNIT

The MCRU includes the Columbia River from the U.S./Canadian border to John Day Dam and its tributaries. The area east of the Okanogan River (upstream from Chief Joseph Dam) is recognized as a

research needs area (formerly Eastern Washington, but retitled Northeastern Washington Research Needs Area). It is also considered a core area in a basic sense, but is unoccupied and more information is required to determine its potential for supporting bull trout in the future. It includes 24 core areas in three distinct groupings: tributaries to the Columbia River between Chief Joseph Dam and McNary Pool, tributaries to the Snake River between Brownlee Dam and the confluence with the Columbia River, and tributaries to the Clearwater River from its headwaters to its confluence with the Snake River.

The mouths of the following tributaries are within the Action Area in the MCRU: Methow River, Entiat River, Wenatchee River, Yakima River, North Fork Clearwater River, Asotin Creek, and Tucannon River (USFWS 2014). There are 16 CHUs designated in the MCRU. These are generally aligned with the core areas, although some CHUs contain multiple core areas. The mainstem of the Columbia River below Chief Joseph Dam (CHU 22) and the Snake River below Brownlee Dam (CHU 23) are designated FMO habitat. The Clearwater River below Dworshak Dam is also designated FMO habitat, but it is incorporated in CHU 21. The FCRPS facilities in the MCRU are located in FMO habitat-only, with the exception of Dworshak reservoir in critical habitat unit 21. FMO habitat is generally outside core area boundaries, but may be used by bull trout from multiple core areas.

Chief Joseph Dam Reach

The Chief Joseph Dam Reach includes three segments—the Columbia River above Grand Coulee Dam to the U.S.-Canada border, Rufus Woods Lake, and the Mid-Columbia Segment downstream to headwaters of the McNary Pool—and is located within the MCRU. Bull trout are rarely present between Grand Coulee Dam and the Canadian border, and that area was excluded from critical habitat designation (50 CFR Part 17 2010). Similarly, the Rufus Woods Lake segment is outside of critical habitat, and documented bull trout presence within this area is low. Therefore, the section below focuses only on the section of the Columbia River between Chief Joseph Dam and the upstream end of the McNary Pool.

The Mid-Columbia segment of the Chief Joseph Dam Reach includes the mainstem Columbia River from Chief Joseph Dam to the upstream end of the McNary Dam Pool. This reach encompasses five non-federal dams and their associated pools on the mainstem Columbia River, in order going downstream: Wells Dam (Douglas County Public Utility District [PUD]); Rocky Reach and Rock Island Dams (Chelan County PUD); and Wanapum and Priest Rapids Dams (Grant County PUD). These dams have completed FERC relicensing subject to individual ESA Section 7 consultation and/or are operating under approved habitat conservation plans. Therefore, for the purpose of this effects analysis, the effects of the action on species and habitat conditions in this reach are limited only to those measurable effects from changes in Chief Joseph Dam operations that are propagated downstream through the reach. They do not include those effects associated with flow variability on pool shorelines, which are a consequence of ongoing system operations that have not changed significantly since 2008.

Effects on the Species

The bull trout core areas within this reach (but not in the action area) are the Methow River, Entiat River, Wenatchee River, and Yakima River. The Proposed Action would have negligible effects on bull trout in these core areas, as they are outside the action area for the Proposed Action. The salmon migration flows that are part of the Proposed Action are generally passed through by the non-project

facilities, but they may assist in maintaining connectivity among the bull trout core areas adjacent to the Columbia River FMO.

The extent of potential downstream passage at Grand Coulee and Chief Joseph Dam is unknown, but there is a low likelihood because so few fish are present upstream of these facilities, and to the extent passage is an issue at the non-federal dams between Chief Joseph and McNary, it has been addressed as part of the consultation on their respective FERC licenses and is part of the environmental baseline. The extent of potential downstream passage at Grand Coulee Dam and Chief Joseph Dam is unknown, but there is a low likelihood because so few fish are present upstream of these facilities. To the extent passage is an issue at the non-federal dams between Chief Joseph and McNary, it has been addressed as part of the consultation on their respective FERC licenses and is part of the environmental baseline.

Effects on Critical Habitat

The mainstem upper Columbia River CHU (CHU 22) is essential for maintaining bull trout distribution within this unique geographic region of the MCRU and conserving the fluvial migratory life history types exhibited by many of the populations from adjacent core areas. Its location between Chief Joseph Dam in the northernmost geographical area and John Day Dam in the southernmost area provides key connectivity for the MCRU. It is essential for maintaining distribution and genetic contributions to the lower Columbia and the Snake Rivers, as well as 13 critical habitat units. Bull trout are known to reside year-round as sub-adults and adults, and migrating adults may use the mainstem Columbia River for up to 9 months. Several studies in the upper Columbia and lower Snake Rivers indicate that migration occurs between the mainstem upper Columbia River CHU and core areas, generally during periods of cooler water temperatures (Barrows et al. 2016b). FMO habitat provided by the mainstem Columbia River is essential for conservation because it supports the expression of the fluvial migratory life history form for multiple core areas.

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

The Proposed Action would be a continuation of the baseline condition and would have insignificant effects on PCE 1 in the Chief Joseph Dam Reach. Although PCE 1 may be present where tributaries and groundwater interact with the mainstem, little is known regarding the ecological significance of this exchange (Corps 2013b).

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action would have insignificant effects on this PCE. The Columbia River would continue to provide FMO habitat and connection to upstream spawning and rearing habitat for bull trout. Chief Joseph and Grand Coulee Dams would remain a physical barrier to upstream and downstream migration, as a continuation of the baseline condition. Maintenance activities at Chief Joseph Dam will continue to include the removal of fish found in turbines activities minimize impacts to bull trout.

Involuntary spill at Chief Joseph and Grand Coulee Dams will continue to be managed to minimize TDG issues, using the deflectors at Chief Joseph installed in 2008 and the system spill priority list. Thus, to the extent that power generation can be prioritized for Grand Coulee and spill for Chief Joseph, negative water quality effects from TDG will be minimized.

Project operations at McNary and John Day dams, specifically the implementation of the flexible spill program, will result in higher TDG levels of 125 percent in 2020. That program will be implemented April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects. Bull trout within the John Day and McNary Pools would potentially be exposed to the higher TDG levels resulting from the Proposed Action. However, GBT is not typically observed in salmonids when TDG levels do not exceed state water quality standards of 120 percent, and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Furthermore, bull trout have not been observed to any extent at either John Day or McNary dams. During the period of 2011 to 2015, only two bull trout were observed at either dam, with both bull trout being observed within the John Day Dam fishway in 2012 (Corps, unpublished data). The flexible spill program also has the potential to impact bull trout due to the increased likelihood of being entrained downstream of a dam as a result of increased spill levels. However, given the rarity of bull trout observations within the John Day or McNary reservoirs, or at either dam, the Proposed Action is not expected to impact bull trout to a measurable extent.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The Proposed Action would have a limited effect on PCE 3 in the Chief Joseph Dam reach. The Columbia River has a diverse and abundant assemblage of fish that should supply subadult and adult bull trout with adequate forage to sustain their growth and energy needs for migration and overwintering. The Proposed Action would not create undue issues for forage organisms. As described above, the Proposed Action includes the flexible spill program that will elevate TDG levels to 125 percent in 2020 during the period of April 10 through June 15 at the lower Columbia River projects (i.e., John Day and McNary reservoirs). The increased level of TDG has the potential to affect the prey base of bull trout. However, bull trout do not appear to use John Day and McNary reservoirs to any great extent, and any impacts to the prey base are not expected to impact bull trout to any measurable extent.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

PCE 4 is present, particularly within the Hanford Reach, and may provide a limited contribution to FMO habitat in this Action Area. However, it has been documented that PCE 4 is not present in Snake and Columbia River reservoirs (USFWS 2010b). While some portions of the mainstem Snake and Columbia Rivers may exhibit complex processes, it is unlikely that these processes provide a significant contribution to bull trout use of these habitats.

PCE 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

Lower temperatures are present outside of the late spring/summer season. Reservoirs act as heat reservoirs with higher temperatures occurring earlier and longer than would occur otherwise so the temperatures exceed this range.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

Not Present

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is not present in the Chief Joseph Dam reach. Chief Joseph Dam and non-federal dams downstream are run-of-river, and inflow is controlled by operations at Grand Coulee and Canadian Dams. Generally, the hydrograph of the mainstem Snake and Columbia Rivers is highly regulated. The effects of a natural hydrograph on bull trout in the action area have not been intensively studied because of the small numbers of bull trout that use these areas.

The future operations of Reclamation irrigation projects (Columbia River Basin Project, Yakima Project, and Umatilla Phase II Project) is expected to have an insignificant hydrologic effect to Columbia River flows in the Chief Joe Dam Reach. The average estimated change in hydrology by month due to Reclamation tributary irrigation project operations on Columbia River flows at key points are summarized in Appendix C. These data include the effects of storage delivery of water for multiple purposes. During the months of July, August, and September, flows in the Columbia River would be diminished by up to 5 to 10 percent (of approximately 150,000 to 70,000 cfs) by the irrigation projects as measured at Priest Rapids Dam, and by up to 4 to 6 percent from May through September (of approximately 300,000 to 78,800 cfs).

Overall, the irrigation depletions would not have a significant effect on this PCE in this reach or downstream reaches or on any bull trout present in the mainstem at that time. This reduction of flow would not impact the function, quality, or availability of the FMO habitat in the Columbia River.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The Proposed Action would have infrequent adverse effects on PCE 8 in the Chief Joseph Dam Reach. Primary water quality concerns in this area include the potential for TDG (in excess of state standards of 110 percent), which can harm fish, but at lesser levels and lower frequency than in the baseline.

The Corps and Reclamation investigated a range of potential methods to reduce TDG generation in the Columbia River mainstem below Chief Joseph Dam. The Corps and Reclamation determined that a combination of operational modifications at Grand Coulee and structural and operational modifications at Chief Joseph provided the most effective solution. Spillway deflectors were completed at Chief Joseph Dam in 2008 and have proven to be effective at reducing TDG during spill operations. A post-deflector study showed reduced TDG exchange in spillway flows with TDG saturations ranging from about 110 to 120 percent (Schneider 2011). For example, in May 2011 when Grand Coulee Dam was releasing 144 percent TDG and the Chief Joseph forebay TDG levels were 140 percent, the flow deflectors reduced TDG levels to 123 percent in the Chief Joseph tailwater.

Continued operation under the Proposed Action would not change water quality conditions compared to the environmental baseline, except during spill events. This reach would continue to provide FMO habitat for bull trout.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Proposed Action would have insignificant effects on PCE 9 in the Chief Joseph Dam Reach.

Dworshak Dam Reach

The Dworshak Dam Reach includes the Dworshak Reservoir on the North Fork of the Clearwater River, the tributaries upstream that are affected by the backwater and elevation changes in the reservoir, the North Fork Clearwater River to the Clearwater mainstem and its confluence with the Snake River, and portions of the Snake River from the confluence with the Clearwater to the Lower Granite Dam. Dworshak Dam and Reservoir are contained entirely within the North Fork Clearwater core area, which includes 12 complex local populations, and its operations also affect FMO habitat in the mainstem Clearwater River and the Snake River.

Effects on the Species

Bull trout upstream of Dworshak Dam are affected by entrainment, although it is expected to be rare (Hanson et al. 2014). The Proposed Action generally maintains baseline operational conditions, indicating that the action is not likely to have any measurable effect on bull trout entrainment rates relative to the environmental baseline. Dworshak Dam is a barrier to upstream and downstream passage and therefore isolates bull trout residing above the dam from other populations in core areas within the basin.

Effects on Critical Habitat

The Dworshak Dam Reach is contained within the Clearwater River CHU 21, which includes the Clearwater River from its confluence with the Snake River near Lewiston, Idaho, upstream through the North, Middle, and South Forks of the Clearwater River, to their headwater streams in the Bitterroot Mountains along the Idaho/Montana border. The portion of the Snake River included in this reach is part of CHU 23, which is considered FMO habitat.

The North Fork Clearwater River CHSU is essential to bull trout conservation because the North Fork Clearwater River Core Area has a large number of local populations that support large numbers of bull trout. The CHSU is also secure, with few threats. This CHSU also includes the Fish Lake core area, which contains one of only two headwater lake adfluvial bull trout populations in the entire Clearwater River CHU. Bull trout within the North Fork Clearwater River CHSU are one of the more secure and stable bull trout core area populations within the Clearwater CHU, which is an important stronghold (USFWS 2015c).

Under the Proposed Action, the Dworshak Temperature Control measure would result in changes in Dworshak Reservoir elevation from June through September. Water levels are consistently lower June 20 through August 1, typically between 3 and 8 feet. From August 1 to August 31, draft slows dramatically and the deeper reservoir transitions to being about 10 feet higher than most No Action Alternative years by August 31. For the first half of September the water levels are about 10 feet higher compared to the No Action Alternative, but then match the No Action Alternative by September 30 at 1,520 feet NGVD29 (NAVD 88).

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

The Proposed Action would have no effect on PCE 1 in the Dworshak Dam Reach. In reservoir environments, subsurface connectivity and thermal refugia are a function of several factors, including thermal stratification within the reservoir, tributary inflow, wetland influence, and groundwater recharge. In deep reservoirs, thermal stratification is typically the primary mechanism providing thermal refugia.

The Proposed Action would have no effect on PCE 1 in the Clearwater River downstream of Dworshak Dam. Railroad and highway development have constrained the river and reduced the connectivity with off-channel habitats. The operation and maintenance of the dam would cause no change in these conditions.

The Proposed Action would have no effect on PCE 1 from the confluence with the lower Snake River to Lower Granite Dam. Although PCE 1 is present where tributaries and groundwater interact with the reservoirs and river, the ecological significance of this exchange is minor and does not contribute to FMO habitat in this reach.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action would have infrequent, adverse effects on this PCE where low reservoir levels and drawdown can affect species migration. The Dworshak Reservoir and Clearwater River would continue to provide FMO habitat and connection to upstream spawning and rearing habitat for bull trout. Dworshak Dam would remain a physical barrier to upstream and downstream migration, as a continuation of the baseline condition. Passage through Dworshak Dam is a contributing threat to bull trout in the core area but is considered minor overall (USFWS 2015d).

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The Proposed Action would have a discountable effect on PCE 3 in the Dworshak Reach. The abundance of prey items is not limiting in this reach (USFWS 2002b), and continued operations under the Proposed Action would not affect the rate of terrestrial organism input or forage fish abundance.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and

unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

The Proposed Action would have discountable effects on PCE 4 in the Dworshak Dam reach. In the Dworshak Reservoir, the water depth, thermal stratification, and shallow shoreline habitat provide the most significant habitat complexity and contribution to FMO habitat. PCE 4 is present in the Clearwater River downstream of Dworshak Dam, but has been functionally reduced by past land management. Continued operations under the Proposed Action would not further reduce the availability of complex habitat, but also would not be likely to increase habitat complexity.

PCE 5: Water temperatures ranging from 2°C to 15°C (36°F to 59°F), with adequate thermal refugia available for temperatures that exceed the upper end of this range.

The Proposed Action would have beneficial effects on PCE 5 in the Dworshak Dam Reach. Operational releases from Dworshak Dam are used to moderate water temperatures in the mainstem Clearwater River and Snake River for the expressed purpose of improving aquatic habitat conditions. The proposed continuation of these operational discharges is expected to maintain beneficial temperature conditions in the Lower Granite pool segment of the Dworshak Dam Reach.

Summer temperature moderation and flow augmentation releases from Dworshak are shaped with the intent to maintain water temperatures at the Lower Granite tailrace fixed monitoring site at or below 68°F (20°C) during summer maxima to protect migrating salmonids. These operational releases are expected to have a beneficial effect on summer water temperatures in the Dworshak Dam Reach.

The Action Agencies use operational releases from Dworshak Dam to moderate water temperatures in the mainstem Clearwater and Snake Rivers for the expressed purpose of improving aquatic habitat conditions. Depending on river flow, the effect of Dworshak cool water augmentation can reach as far downstream as Ice Harbor Dam. Although temperatures are improved, they still exceed optimal levels for bull trout below Little Goose Dam.

PCE 6: In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo over-winter survival, fry emergence, and young-of-the-year and juvenile survival.

The Proposed Action would have insignificant effects on PCE 6 in the Dworshak Dam Reach. Subadult and adult bull trout occupy Dworshak Reservoir (CBBTTAT 1998; Cichosz et al. 2001; Schiff and Schreiver 2004), but spawning does not occur there. Although the reservoir does influence the North Fork Clearwater River, tributaries that are used for bull trout spawning are only indirectly influenced by dam operations. The Clearwater River downstream of Dworshak Dam does not contain spawning and rearing habitat but does provide FMO habitat and connectivity to tributaries in the Clearwater River Basin (USFWS 2014). In the mainstem lower Snake River, bull trout spawning does not occur. The Asotin Creek watershed provides spawning habitat but in areas above the influence of dam operations, i.e., outside the action area. Continuing operations under the Proposed Action would not change the amount of spawning and rearing habitat available in this reach

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

The Proposed Action would have insignificant effects on PCE 7 in the Dworshak Dam Reach. PCE 7 addresses the timing and amount of streamflow, a characteristic that is, by definition, not present in a reservoir environment. PCE 7 is present and contributes to FMO in the Clearwater River, although the mainstem Clearwater River reach below the confluence with the North Fork is influenced by Dworshak Dam operations (Ecovista et al. 2003). Although the hydrograph varies from the natural hydrograph, continuing operations under the Proposed Action would not further reduce availability of bull trout habitat relative to the hydrograph in the Dworshak Dam Reach.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The Proposed Action would have infrequent adverse effects on PCE 8 in the Dworshak Dam Reach during involuntary spill events. Primary water quality concerns in this area include the potential for dissolved gas supersaturation (in excess of state standards of 110 percent), which can harm fish, but at lesser levels and lower frequency than in the baseline.

The Corps continuously monitors TDG levels in the tailrace below Dworshak Dam. TDG monitoring conditions downstream of the Dworshak Dam were improved in 2010 with the extension of a deployment pipe near the Dworshak National Fish Hatchery. The deployment pipe was extended approximately 30 feet to facilitate water circulation around the TDG sensor.

Continued operation under the Proposed Action would not change water quality conditions compared to the environmental baseline. This reach would continue to provide limited FMO habitat for bull trout.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Proposed Action would have insignificant effects on PCE 9 in the Dworshak Dam Reach. PCE 9 would continue to be impaired by the presence of non-native brook trout, which is identified as a threat in the North Fork Clearwater River (USFWS 2014). Continued operations under the Proposed Action would not affect the level of this species.

Lower Snake River Dams and Reservoirs Reach

The lower Snake River Dams and Reservoirs reach includes four federal dams and mainstem habitats from the McNary Pool upstream to Lower Granite Dam. Also included in this reach are the lower reaches of contributing tributaries in each reservoir, to the extent that surface water elevations are influenced by dam operations. The operation of these four dams has been modified significantly since 2008 to aid passage of juvenile and adult fish through the lower Snake River. Project elements, species-level effects, and effects on critical habitat PCEs are similar throughout this reach, and the discussion of effects in each segment has been consolidated accordingly.

The Lower Granite pool segment of the lower Snake River Dams and Reservoirs reach includes the Snake River from Lower Granite Dam upstream to the confluence with the Clearwater River, as well as the upstream portion of the Snake River within the backwater effect of the Lower Granite pool extending approximately to the confluence with Asotin Creek. The Lower Granite Dam to Little Goose Dam

segment includes the Little Goose Dam pool on the Snake River between the aforementioned dams. The Little Goose Dam to Lower Monumental Dam segment includes the Lower Monumental Dam pool on the Snake River between the aforementioned dams. The Lower Monumental Dam to Ice Harbor Dam segment includes the Ice Harbor Dam pool on the Snake River between the aforementioned dams. The Ice Harbor Dam to Lake Wallula (McNary pool) segment includes the Snake River from Ice Harbor Dam downstream to the confluence with the Columbia River.

The Tucannon River and the Palouse River are the two main tributaries in this reach and both enter the Snake River in the lower portion of Lower Monumental Reservoir. The Tucannon River contains the last remaining viable bull trout population in the area and is a core area for the MCRU for bull trout recovery (USFWS 2015c). Meadow and Deadman Creeks are smaller tributaries to Little Goose Reservoir, but do not contain bull trout and are not designated as critical habitat.

Effects on the Species

The Snake River contains FMO habitat for migrating bull trout. Implementation of the Proposed Action would include the continuation of current operations. In the FCRPS 2000 BiOp, USFWS concluded that information on bull trout use of Snake River reservoir habitat was limited, and therefore, determining the effects of FCRPS operations on the species was also limited. Subsequent studies and annual reports of bull trout behavior indicate use of Snake River reservoir habitat by migratory subadult and adult bull trout (Barrows et al. 2016b).

Effects on Critical Habitat

The mainstem Snake River in this reach is included in CHU 23. The Tucannon River core area is encompassed by the lower Snake River Basins CHU 15. The lower Snake River Basins CHU is essential to the conservation of bull trout because both migratory and resident bull trout life history forms occur in Asotin Creek and the Tucannon River, and these basins are the only suitable bull trout refugia with adequate spawning, rearing, and FMO habitat in the lower Snake River Basin.

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

PCE 1 is not present in lakes and reservoirs in the Snake and Columbia River CHUs (USFWS 2010b). Some groundwater influence may occur in riverine areas not dominated by bedrock or immediately below dams, although little is known regarding the ecological significance of this exchange (Corps 2013a).

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action would have potential infrequent adverse effects on this PCE. The lower Snake River would continue to provide FMO habitat and connection to upstream spawning and rearing habitat for fluvial migratory bull trout. Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, and Ice Harbor Dam would remain a physical impediment to upstream and downstream migration, as a continuation of the baseline condition. Bull trout have been observed at all of the lower Snake River

dams, smolt monitoring traps, juvenile fish facilities, and fish ladders. Observations have been rare at Lower Granite and Ice Harbor Dams, but increase at other projects downstream. Bull trout counts at Lower Monumental typically range from 2 to 25 individuals. Bull trout observations are most common at Little Goose Dam, where 85 individuals were observed in 2011, and typical counts are around 40 individuals (Barrows et al. 2016a). Bull trout from the Tucannon River have been observed in the mainstem Snake River.

Bull trout migrating downstream during periods of spill may benefit from increased water over spillways and through juvenile passage systems rather than passage through turbines. In contrast, bull trout upstream may be adversely affected by an increased fallback rate or other forms of migration delay associated with spill. Bull trout fallback over lower Snake River dams has not been studied directly, but detailed surveys at mainstem Columbia River dams have not observed significant bull trout fallback or migration delay (BioAnalysts 2002; LGL and Douglas PUD 2008; GCPUD 2014).

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The Proposed Action would have a negligible effect on PCE 3 in the lower Snake River Dam reach. The abundance of prey items is not limiting in this reach (USFWS 2002a), and continued operations under the Proposed Action would not affect the rate of terrestrial organism input or forage fish abundance.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Generally, PCE 4 is not present in Snake and Columbia River reservoirs (USFWS 2010). The mainstem habitat is composed of deep reservoirs with little to no habitat complexity. Only a few tributaries enter the reservoirs. A few backwater areas have been inundated by the impoundment. Recruitable LWD is limited in the lower Snake River reservoirs, and off-channel habitats are scarce. The steep shorelines and arid landscape associated with project reservoirs limit development of riparian communities. Reservoir habitat in this reach is generally uniform and does not form complex pool habitat common in smaller streams.

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is present but provides a limited contribution to FMO habitat in the mainstem Snake and Columbia Rivers. Generally, the hydrograph of the mainstem Snake and Columbia Rivers is highly regulated; storage dams in the Columbia River Basin have dampened the natural hydrograph, with decreased high flows during the summer and increased low flows during the winter. The effects of a natural hydrograph on bull trout in the action area have not been intensively studied because of the small numbers of bull trout that use these areas.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The Proposed Action would have potential infrequent adverse effects on PCE 8 in the lower Snake River Dams and Reservoirs reach. Water quality in the mainstem Snake River is also limited by several pollutants, including sediment, bacteria, dissolved oxygen, nutrients, pH, mercury, pesticides, and total dissolved gas (ODEQ 2013; WDOE 2013). Implementation of the flexible spill program will result in higher TDG levels of 125 percent in 2020. That program will be implemented April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects. Bull trout within the lower Snake River Dams and Reservoirs reach would potentially be exposed to the higher TDG levels resulting from the Proposed Action. However, GBT is not typically observed when TDG levels do not exceed state water quality standards of 120 percent, and generally do not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). The flexible spill program also has the potential to impact bull trout due to the increased likelihood of being entrained downstream of a dam as a result of increased spill levels. However, the Proposed Action is not expected to impact bull trout to a measurable extent.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Currently, 17 non-native fish species share resources with 18 native species in the lower Snake River reservoirs (Bartel et al. 2001). Crappies, sunfish, and largemouth bass are highly abundant in the backwaters of all reservoirs. The highest densities of smallmouth bass in the Columbia and Snake Rivers occur in the Lower Granite forebay, tailrace, and reservoir (NMFS 2000). In a recent study, Erhardt et al. (2018) found that total loss of juvenile Chinook salmon to smallmouth bass predation in Lower Granite Reservoir has increased substantially since the mid-1990s, when the last predation study (Naughton et al. 2004) was conducted. Erhardt et al. (2018) sampled various parts of the Lower Granite Reservoir and estimated that from 2013 to 2015, a total of over 300,000 juvenile Chinook salmon were consumed by smallmouth bass. The Proposed Action will have negligible effects on PCE 9 in the lower Snake River Dams and Reservoirs reach because it will not influence the species that are already present.

McNary Dam to John Day Dam Reach

The McNary Dam Reach includes the Columbia River from the upper extent of Lake Wallula (upstream of McNary Dam) downstream through Lake Umatilla (upstream of John Day Dam) and the lower reaches of contributing tributaries, to the extent that surface water elevations are influenced by dam operations. The Walla Walla and Umatilla Rivers are tributaries that enter this reach. Between 2006 and 2015, a total of four bull trout were observed in McNary Dam ladders, based on visual counts and PIT detections. At John Day Dam, a total of three bull trout have been counted in the fish ladders from 2006–2015 (Barrows et al. 2016b).

Effects on the Species

Bull trout could potentially be affected by entrainment. The current action generally maintains these operational conditions, indicating that the action is not likely to have a measurable effect on bull trout passage rates relative to the environmental baseline.

Effects on Critical Habitat

The major tributaries to this reach include several bull trout core areas under the MCRU. The mainstem is located in CHU 22. The Yakima (CHU 11) and Walla Walla (CHU 14) River watersheds are tributaries to McNary Reservoir, and the Umatilla (CHU 13) and John Day (CHU 12) Rivers flow into John Day Reservoir.

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

PCE 1 is not present in lakes and reservoirs in the Snake and Columbia River CHUs (USFWS 2010). The Proposed Action would have no effect on PCE 1 in the mainstem riverine reach from McNary Dam to John Day Reach. Although PCE 1 is present where tributaries and groundwater interact with the mainstem, the ecological significance of this exchange is minor and does not provide a significant contribution to FMO habitat for bull trout in this reach.

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action would have potential infrequent adverse effects on this PCE. The McNary Dam to John Day Reach would continue to provide FMO habitat and connection to upstream spawning and rearing habitat for fluvial migratory bull trout. McNary Dam and John Day Dam would remain a physical impediment to upstream and downstream migration, as a continuation of the baseline condition. Few bull trout have been observed in this reach.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The Proposed Action would have no effect on PCE 3 in the McNary to John Day Dam Reach. The mainstem Columbia River, including the reservoirs, provides an abundant food source for migratory bull trout during the fall, winter, and spring. Forage fish such as juvenile salmon and steelhead provide a large forage base for bull trout, as well as whitefish, sculpins, suckers, and minnows that inhabit the reservoir (USFWS 2015c). Continued operations under the Proposed Action would not affect the rate of terrestrial organism input or prey abundance.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

PCE 4 may provide a limited contribution to FMO habitat in the mainstem Snake and Columbia Rivers. Generally, PCE 4 is not present in Snake and Columbia River reservoirs (USFWS 2010, p.63934). Riparian areas along the mainstem Columbia River are generally narrow in this project reach, and their structure and condition are influenced by daily fluctuations in river level due to dam operations (50 CFR Part 17 2010). Residential, agricultural and recreational development along the mainstem has also resulted in the loss of riparian vegetation. The Umatilla National Wildlife Refuge was established in 1969 for

mainstem wildlife habitat lost to flooding caused by the construction of the John Day Dam and is located along both sides of the Columbia River in this section. The 25,347-acre refuge includes open water, shallow marshes, backwater sloughs, croplands, islands, and shrub-steppe uplands.

The future operations of Reclamation irrigation projects (inclusive of Columbia River Basin, Yakima, Umatilla Phase I and II, Deschutes, Crooked River, and Wapinitia projects) is expected to have an insignificant hydrologic effect to Columbia River flows in the McNary Dam to John Day Dam Reach. The average estimated change in hydrology by month due to Reclamation tributary irrigation project operations on Columbia River flows at key points are summarized in Appendix C. These data include the effects of storage delivery of water for multiple purposes. Typically, from April through September, flows in the Columbia River would be diminished by up to 4 percent (inclusive of The Dalles, which is downstream of this reach) of up to approximately 310,000 cfs as measured at Bonneville Dam.

Overall, the irrigation depletions would not have a significant effect on this PCE or on any bull trout present in the mainstem at that time. This reduction of flow would not impact the function, quality, or availability of the FMO habitat in the Columbia River.

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is present but functionally impaired and flows in this reach are highly influenced by storage dam operations in the upper watershed. Overall, storage dams in the Columbia River Basin have dampened the natural hydrograph with decreased high flows during the summer and increased low flows during the winter (National Research Council 2004). The Proposed Action will not measurably change the hydrograph in this reach.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

Implementation of the flexible spill program will result in higher TDG levels of 125 percent in 2020. That program will be implemented April 3 through June 20 at the lower Snake River projects, and April 10 through June 15 at the lower Columbia River projects. Bull trout within the John Day and McNary Pools would potentially be exposed to the higher TDG levels resulting from the Proposed Action. However, GBT is not typically observed when TDG levels do not exceed state water quality standards of 120 percent, and generally does not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Furthermore, bull trout have not been observed to any extent at either John Day or McNary dams. The flexible spill program also has the potential to impact bull trout due to the increased likelihood of being entrained downstream of a dam as a result of increased spill levels. However, given the rarity of bull trout observations within the John Day or McNary Reservoirs, or at either dam, the Proposed Action is not expected to impact bull trout to a measurable extent.

Continued operation under the Proposed Action would not change water quality conditions compared to the environmental baseline. This reach would continue to provide limited FMO habitat for bull trout.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Proposed Action would have insignificant effects on PCE 9 in the McNary to John Day Dam Reach. There are 36 non-native fish species in the lower Columbia River. Some of these species may compete with bull trout for food resources. Bull trout do not spawn in the mainstem of the Columbia River, so there is low risk for hybridization with brook trout.

PCE 9 would continue to be impaired by the presence of non-native species, but continuation of current operations under the Proposed Action would not affect the level of introduced species.

COASTAL RECOVERY UNIT

The Coastal Recovery Unit is divided into two geographic regions: the lower Columbia River, along with the Puget Sound/Olympic Peninsula, which is outside the action area. The lower Columbia River geographic unit runs from John Day Dam to the Columbia River Mouth. The lower Columbia River region contains seven core areas (Lewis River, Klickitat River, Hood River, lower Deschutes River, upper Willamette River, Odell Lake, and Clackamas River). The mainstem Columbia River in this recovery unit is within the mainstem lower Columbia River CHU 8 and is considered FMO habitat.

The only core areas currently supporting anadromous populations of bull trout are located within the Puget Sound and Olympic Peninsula regions. Although bull trout in the lower Columbia River region share a genetic past with the Puget Sound and Olympic Peninsula regions, it is unclear to what extent the lower Columbia River core areas supported the anadromous life history in the past or could in the future (Ardren et al. 2011). Adult bull trout are still occasionally observed within the lower mainstem Columbia River, but any further migration by bull trout in this region to the Pacific Ocean is largely unknown.

The action area in the mainstem of the Columbia River below John Day Dam is within CHU 8, which is designated FMO habitat. FMO habitat is generally outside core area boundaries but may be used by bull trout from multiple core areas.

Lower Columbia River Dams and Pools Reach

The lower Columbia River Dams and pools reach is composed of three sections: the John Day Dam segment, extending from John Day Dam downstream to The Dalles Dam; The Dalles segment extending from the Dalles Dam downstream to Bonneville Dam; and the Bonneville Dam segment, which extends from the Bonneville Dam downstream to the confluence of the Columbia River and the Willamette River.

Historically, the lower Columbia River region is believed to have largely supported the fluvial life history form; however, non-federal hydroelectric facilities built within a number of the core areas have isolated or fragmented watersheds and largely replaced the fluvial life history with the adfluvial form.

Effects on the Species

Bull trout could potentially be affected by passage. Under the Proposed Action, bull trout may encounter CRS fishways as they migrate upstream through the lower Columbia River. Fish migrating upstream of Bonneville Dam would benefit from modifications to the Bonneville Dam upper ladder

serpentine flow control ladder sections. Bull trout that potentially migrate downstream from John Day Dam through the powerhouse would benefit from improved fish passage turbines.

The Proposed Action also includes the flexible spill program, which will result in higher TDG levels of 125 percent in 2020. That program will be implemented April 10 through June 15 at the lower Columbia River projects. Bull trout within the lower Columbia River would potentially be exposed to the higher TDG levels resulting from the Proposed Action. However, GBT is not typically observed in salmonids when TDG levels do not exceed state water quality standards of 120 percent, and generally does not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Furthermore, bull trout have not been observed to any extent within the lower Columbia River. During the period of 2011 to 2015, only two bull trout were observed at any lower Columbia River dam, with both bull trout being observed within the John Day Dam fishway in 2012 (Corps, unpublished data). The flexible spill program also has the potential to impact bull trout due to the increased likelihood of being entrained downstream of a dam as a result of increased spill levels. However, given the rarity of bull trout observations within the lower Columbia River, the Proposed Action is not expected to impact bull trout to a measurable extent.

As under the current operations, bull trout passage could occasionally be delayed at John Day Dam, The Dalles Dam, and Bonneville Dam, but observations of bull trout in this reach of the river have been infrequent. Since bull trout are infrequently observed and passage facilities are available at the dam, migration effects on bull trout would be minimal.

Effects on Critical Habitat

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

PCE 1 is not present in lakes and reservoirs in the Snake and Columbia River CHUs (USFWS 2010b). Some groundwater influence may occur in riverine areas not dominated by bedrock or immediately below dams, although little is known regarding the ecological significance of this exchange (Corps 2013a).

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action would have no effect on this PCE. The Columbia River would continue to provide FMO habitat and connection to spawning and rearing habitat for bull trout. As under the baseline condition, bull trout upstream passage could occasionally be delayed at John Day Dam, The Dalles Dam, and Bonneville Dam, but observations of bull trout in this reach of the river have been infrequent. Since bull trout are infrequently observed and passage facilities are available at the dam, migration effects on bull trout would be minimal.

The flexible spill program as defined in the Proposed Action for juvenile fish passage during spring and summer months partially overlaps the period when bull trout migrate from Columbia River mainstem reservoirs to tributary habitats. This suggests the potential for mixed effects on bull trout migrating past the John Day Dam from the John Day Pool to downstream tributaries (e.g., the Klickitat and Hood Rivers)

and from The Dalles Pool to upstream tributaries (e.g., the Umatilla and Walla Walla Rivers), should such migration occur. Bull trout migrating to downstream tributaries during fish passage spill may benefit from increased water over spillways rather than passage through powerhouses (i.e., improved survival). In contrast, upstream migrant bull trout may be adversely affected by an increased fallback rate or other forms of migration delay associated with spill.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The Proposed Action would have no effect on PCE 3 in the lower Columbia River dams and pools reach. The mainstem Columbia River, including the reservoirs, provides an abundant food source for migratory bull trout, including juvenile salmon and steelhead and forage fish species. Continued operations under the Proposed Action would not affect the rate of terrestrial organism input or prey abundance.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

PCE 4 may provide a limited contribution to FMO habitat in the mainstem Snake and Columbia Rivers. However, it is not anticipated that the Proposed Action will have measurable effects on PCE 4 in the lower Columbia River.

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is present but functionally impaired. It provides a limited contribution to FMO habitat in the mainstem Snake and Columbia Rivers. Generally, the hydrograph of the mainstem Snake and Columbia Rivers is highly regulated. The effects of a natural hydrograph on bull trout in the action area have not been intensively studied because of the small numbers of bull trout that use these areas.

While the Proposed Action will result in a minor decrease in flow when bull trout may reside within the lower Columbia River, this decrease is not expected to impact bull trout to any measurable extent.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The Proposed Action will have an impact on PCE 8 in the lower Columbia River reach. The Proposed Action will increase allowable TDG levels to 125 percent of saturation beginning in 2020. However, GBT is not typically observed in salmonids when TDG levels do not exceed 120 percent of saturation, and generally does not become more pronounced until TDG levels exceed 125 percent of saturation (NMFS 2019). Given that bull trout do not appear to use the lower Columbia River to any great extent, and observations indicate TDG levels less than 125 percent saturation do not have profound impacts to salmonids, the Proposed Action is not expected to have measurable impacts on bull trout for this PCE.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Proposed Action would have insignificant effects on PCE 9 in the lower Columbia River dams and pools reach. Introduced species are present throughout this reach. PCE 9 would continue to be impaired by the presence of non-native species, but continuation of current operations under the Proposed Action would not affect the level of introduced species.

Lower Columbia River Estuary Reach

The lower Columbia River estuary (LCRE) reach includes the lower reach of the Columbia River, from the confluence of the Willamette River downstream to the mouth.

Despite a lack of definitive information documenting bull trout use of the LCRE, the Lower Columbia Technical Recovery Team believes that the estuary and mainstem provide core habitat that may be important for species recovery (USFWS 2015a). The action area in the lower Columbia River estuary reach is within CHU 8, which is designated FMO habitat.

Effects on the Species

Bull trout abundance in the lower Columbia River Basin is lower relative to the upper Columbia River, where there is better habitat and connectivity in tributaries (USFWS 2015a). From 2006 to 2015, three bull trout have been counted in fish ladders at Bonneville and The Dalles Dams and one bull trout has been captured in the smolt monitoring facility at Bonneville Dam (Barrows et al. 2016b). While this suggests that there is potential for bull trout to be entrained through turbines, spillways, or other water passage routes at these dams, the frequency of these events is likely low.

Effects on Critical Habitat

PCE 1: Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

PCE 1 is not present in lakes and reservoirs in the Snake and Columbia River CHUs (USFWS 2010). Some groundwater influence may occur in riverine areas not dominated by bedrock or immediately below dams, although little is known regarding the ecological significance of this exchange (Corps 2013a).

PCE 2: Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, over-wintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

The Proposed Action would have no effect on this PCE. The Columbia River would continue to provide FMO habitat and connection to high-quality spawning and rearing habitat for bull trout. Bull trout have not been documented in the estuary since at least the 1970s, and any potential effects on bull trout from continuing operations would be non-detectable.

PCE 3: An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

The Proposed Action would have no effect on PCE 3 in the lower Columbia River estuary reach. The mainstem Columbia River provides an abundant food source for migratory bull trout, including juvenile salmon and steelhead and forage fish species. Continued operations under the Proposed Action would not affect the rate of terrestrial organism input or prey abundance.

PCE 4: Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks, and unembedded substrates to provide a variety of depths, gradients, velocities, and structure.

Generally, PCE 4 is not present in the Snake and Columbia River reservoirs (USFWS 2010). PCE 4 may provide a limited contribution to FMO habitat in the mainstem Snake and Columbia Rivers. While some portions of the mainstem Snake and Columbia Rivers may exhibit complex processes, it is unlikely these processes provide a significant contribution to bull trout use of these habitats.

PCE 7: A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

PCE 7 is present but functionally impaired in this reach. It provides a limited contribution to FMO habitat in the mainstem Snake and Columbia Rivers. Generally, the hydrograph of the mainstem Snake and Columbia Rivers is highly regulated. The effects of a natural hydrograph on bull trout in the action area have not been intensively studied because of the small numbers of bull trout that use these areas. Although the hydrograph varies from the natural hydrograph, continuing operations under the Proposed Action would not further reduce availability of bull trout habitat relative to the hydrograph in the lower Columbia River estuary reach.

The future operations of Reclamation irrigation projects (inclusive of Columbia River Basin, Yakima, Umatilla Phase I and II, Deschutes, Crooked River, Wapinitia, The Dalles, and Tualatin Projects) is expected to have an insignificant hydrologic effect to Columbia River flows down to and including the estuary. The average estimated change in hydrology by month due to the Reclamation tributary irrigation project operations on Columbia River flows at key points are summarized in Appendix C. These data include the effects of storage delivery of water for multiple purposes. During the months of May through September, depletions may be up to approximately 11,100 cfs at the estuary, which is a fraction of the total flow from the Columbia. Given that this is such a small percentage of overall flow, the irrigation depletions would not have a significant effect on this PCE or on any bull trout present in the mainstem at that time. This reduction of flow would not impact the function, quality, or availability of the FMO habitat in the Columbia River or the estuary.

PCE 8: Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

The Proposed Action would have insignificant effects on PCE 8 in the LCRE reach. Water quality is generally degraded in this reach due to a legacy of urban, industrial, and agriculture practices. Continued operation under the Proposed Action would not change water quality conditions compared to the environmental baseline. Potential increase in TDG from the flex spill program will not affect this reach because the effects of spill operations attenuate downstream of Bonneville Dam. This reach would continue to provide limited FMO habitat for bull trout.

PCE 9: Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), interbreeding (e.g., brook trout), or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

The Proposed Action would have insignificant effects on PCE 9 in the LCRE Reach. Introduced species are present throughout this reach. PCE 9 would continue to be impaired by the presence of non-native species, but continuation of current operations under the Proposed Action would not affect the level of introduced species.

3.3.1.5 Summary of Effects to Critical Habitat

Hydrologic effects to PCEs in the action area are summarized below by project.

MAINSTEM COLUMBIA AND SNAKE RIVERS

For the mainstem Columbia and Snake Rivers, the USFWS did not consider PCEs 5 and 6 as features necessary to support bull trout use of that habitat (USFWS 2010). Likewise, for lakes and reservoirs of those critical habitat units, the USFWS did not consider PCEs 1, 4, and 6 to be necessary features. Therefore, effects to PCEs 5 and 6 were not analyzed on the mainstem Columbia and Snake Rivers, and PCEs 1, 4, and 6 were not analyzed in the reservoirs on the Columbia and Snake Rivers.

Libby Dam Reach

The hydrologic effects to PCEs on Libby Dam Reach on bull trout critical habitat are presented in Table 3-70.

Table 3-70. Summary comparison of the effects of the Proposed Action to current conditions for Libby Dam Reach on bull trout critical habitat

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action	
		Lake Koocanusa and Tributaries	Kootenai River (downstream)
1	Springs, seeps, groundwater sources	No effect	No effect
2	Migration habitats with minimal impediments.	No effect	No effect
3	Abundant food base	Insignificant effect	Insignificant effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	No effect	No effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	No effect	No effect
6	Spawning/rearing substrate.	No effect	No effect
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present	Adverse seasonal effects
8	Sufficient water quality and quantity	No effect	No effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	No effect	No effect

Hungry Horse Reach

The hydrologic effects to PCEs on Hungry Horse Reach on bull trout critical habitat are presented in Table 3-71.

Table 3-71. Summary comparison of the effects of the Proposed Action to current conditions for Hungry Horse Reach on bull trout critical habitat

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action	
		Hungry Horse Reservoir and Tributaries	Flathead River (downstream)
1	Springs, seeps, groundwater sources	No effect	No effect
2	Migration habitats with minimal impediments.	No effect	No effect
3	Abundant food base	Beneficial	Beneficial
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect	Insignificant effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	Insignificant effect	Insignificant effect
6	Spawning/rearing substrate	Not present	Insignificant effect
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present	Insignificant effect
8	Sufficient water quality and quantity	Insignificant effect	Insignificant effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect	Not present

Albeni Falls Reach

The hydrologic effects to PCEs on Albeni Falls Reach on bull trout critical habitat are presented in Table 3-72.

Table 3-72. Summary comparison of the effects of the Proposed Action to current conditions for Albeni Falls Reach on bull trout critical habitat

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action	
		Pend Oreille Lake and Tributaries	Pend Oreille River Downstream
1	Springs, seeps, groundwater sources	Insignificant	Insignificant
2	Migration habitats with minimal impediments	No effect	No effect
3	Abundant food base	Discountable effect	Discountable effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect	Insignificant effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	Discountable effect	Discountable effect
6	Spawning/rearing substrate	Not present	Not present

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action	
		Pend Oreille Lake and Tributaries	Pend Oreille River Downstream
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present	Insignificant effect
8	Sufficient water quality and quantity	Insignificant effect	Insignificant effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect	Insignificant effect

Chief Joseph Dam Reach

The hydrologic effects to PCEs on Chief Joseph Dam Reach (the Columbia River between Chief Joseph Dam and the upstream extent of the McNary Pool) on bull trout critical habitat are presented in Table 3-73.

Table 3-73. Summary comparison of the effects of the Proposed Action to current conditions for Chief Joseph Dam Reach

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
1	Springs, seeps, groundwater sources	Insignificant effect
2	Migration habitats with minimal impediments.	Insignificant effect
3	Abundant food base	Insignificant effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	Not present
6	Spawning/rearing substrate	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present
8	Sufficient water quality and quantity	Infrequent adverse effects
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect

Dworshak Reach

The hydrologic effects to PCEs on Dworshak Reach (Dworshak Reservoir and Tributaries, North Fork Clearwater River to the Clearwater River mainstem and its confluence with the Snake River, and portion of the Snake River downstream to lower Granite Dam) on bull trout critical habitat are presented in Table 3-74.

Table 3-74. Summary comparison of the effects of the Proposed Action to current conditions for Dworshak Reach

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action		
		Dworshak Reservoir and Tributaries	North Fork Clearwater	Snake River
1	Springs, seeps, groundwater sources	No effect	No effect	No effect
2	Migration habitats with minimal impediments	Infrequent adverse effects	Infrequent adverse effects	Adverse effect
3	Abundant food base	Discountable effect	Discountable effect	Discountable effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Discountable effect	Discountable effect	Discountable effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	Beneficial	Beneficial	Not present
6	Spawning/rearing substrate	Not present	Not present	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Not present	Insignificant effect	Insignificant effect
8	Sufficient water quality and quantity	Infrequent adverse effect	Infrequent adverse effect	Infrequent adverse effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect	Insignificant effect	Insignificant effect

Lower Snake River Dams and Reservoir Reach

The hydrologic effects to PCEs on the Lower Snake River Dams and Reach on bull trout critical habitat are presented in Table 3-75.

Table 3-75. Summary comparison of the effects of the Proposed Action to current conditions for the lower Snake River Dams and Reservoir Reach

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
1	Springs, seeps, groundwater sources	Not present
2	Migration habitats with minimal impediments.	Infrequent adverse effect
3	Abundant food base	Discountable effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	Not present
6	Spawning/rearing substrate	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Insignificant effect
8	Sufficient water quality and quantity	Infrequent adverse effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect

McNary Dam to John Day Reach

The hydrologic effects to PCEs from McNary Dam to John Day Dam Reach on bull trout critical habitat are presented in Table 3-76.

Table 3-76. Summary comparison of the effects of the Proposed Action to current conditions for the McNary Dam to John Day Dam Reach

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
1	Springs, seeps, groundwater sources	Not present
2	Migration habitats with minimal impediments.	Discountable effect
3	Abundant food base	No effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	Not present
6	Spawning/rearing substrate	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Insignificant effect
8	Sufficient water quality and quantity	Infrequent adverse effects
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect

Lower Columbia River Dams and Pool Reach

The hydrologic effects to PCEs on the Lower Columbia River Dams and Pool Reach (John Day Dam to Bonneville Dam) on bull trout critical habitat are presented in Table 3-77.

Table 3-77. Summary comparison of the effects of the Proposed Action to current conditions for the lower Columbia River

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
1	Springs, seeps, groundwater sources	Not present
2	Migration habitats with minimal impediments	No effect
3	Abundant food base	No effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	Not present
6	Spawning/rearing substrate	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Insignificant effect
8	Sufficient water quality and quantity	Insignificant effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect

Lower Columbia River Estuary Reach

The hydrologic effects to PCEs on the Lower Columbia River Estuary Reach (mainstem Columbia River from Bonneville Dam to the mouth of the Columbia River) on bull trout critical habitat are presented in Table 3-78.

Table 3-78. Summary comparison of the effects of the Proposed Action to current conditions for the lower Columbia River Estuary Reach

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
1	Springs, seeps, groundwater sources	Not present
2	Migration habitats with minimal impediments	No effect
3	Abundant food base	No effect
4	Complex river, stream, lake, and reservoir aquatic environments and process	Insignificant effect
5	Water temps ranging from 2°–15°C with adequate thermal refugia	Not present
6	Spawning/rearing substrate	Not present
7	A natural hydrograph, or if flows are controlled, minimal flow departure from a natural hydrograph	Insignificant effect
8	Sufficient water quality and quantity	Insignificant effect
9	Sufficiently low levels of nonnative predatory; interbreeding; or competing species	Insignificant effect

3.3.1.6 Summary of Effects of the Action

The Proposed Action may adversely affect bull trout at Libby Dam through passage; at Hungry Horse through potential entrainment; and at Albeni Falls Dam through entrainment. At Grand Coulee and Chief

Joseph, the extent of potential passage is unknown because so few bull trout are present above the dams; if any are present, they may also be subjected to decreased water quality conditions. At Dworshak Dam, bull trout may be adversely affected through passage, migration impediments during reservoir drawdown, and decreased water quality. For the lower Snake River dams and reservoirs, bull trout are adversely affected by passage, delayed upstream or downstream migration, and by decreased water quality in the form of increased TDG. For the mainstem Columbia River from Chief Joseph Dam to the river mouth and estuary, bull trout may be adversely affected by passage, delayed migration (minimal), and decreased water quality in the form of increased TDG.

3.3.2 Kootenai River White Sturgeon

3.3.2.1 Range-wide Status of Kootenai River White Sturgeon and Critical Habitat

White sturgeon are included in the family Acipenseridae, which consists of four genera and 24 species of sturgeon. Eight species of sturgeon occur in North America; white sturgeon are one of the five species in the genus *Acipenser*. The Kootenai River white sturgeon is one of 18 landlocked populations of white sturgeon known to occur in western North America [USFWS (1999), pg. 3]. Kootenai River white sturgeon have been genetically isolated from other white sturgeon in the CRS for approximately 10,000 years by the impassable barrier of Bonnington Falls.

White sturgeon were first described by Richardson in 1863 from a single specimen collected in the Columbia River near Fort Vancouver, Washington [Scott and Crossman (1973) as cited in NPCC (2013), pg. 371]. White sturgeon are distinguished from other *Acipenser* species by the specific arrangement and number of scutes (bony plates) along the body [Scott and Crossman (1973) as cited in NPCC (2013), pg. 371]. The largest white sturgeon on record, weighing approximately 1,500 pounds, was taken from the Snake River near Weiser, Idaho in 1898 [Simpson and Wallace (1978), pg. 51]. The largest white sturgeon reported among Kootenai sturgeon was a 159-kilogram (350-pound) individual, estimated at 85 to 90 years of age, captured in Kootenay Lake during September 1995 [R. L. & L. Environmental Services Ltd. (1999), pg. 8]. White sturgeon are generally long-lived, with females living from 34 to 70 years [(PSMFC 1992; p. 19), pg. 19].

REGULATORY STATUS

Listing: On June 11, 1992, the USFWS received a petition from the Idaho Conservation League, North Idaho Audubon, and the Boundary Backpackers to list the Kootenai sturgeon as threatened or endangered under the ESA. The petition cited lack of natural flows affecting juvenile recruitment as the primary threat to the continued existence of the wild Kootenai sturgeon population. Pursuant to section 4(b)(A) of the ESA, the USFWS determined that the petition presented substantial information indicating that the requested action may be warranted, and published this finding in the *Federal Register* on April 14, 1993 (58 FR 19401 1993).

A proposed rule to list the Kootenai River white sturgeon as endangered was published in the *Federal Register* on July 7, 1993 (58 FR 36379 1993), with a final rule following on September 6, 1994 (59 FR 45989).

Critical Habitat: On September 6, 2001, USFWS designated critical habitat (Figure 3-32), which was revised in 2006 and finalized in 2008 (73 FR 39505 2008) for white sturgeon, consisting of 18.3 miles from approximately RM 159.7, past the confluence of the Kootenai River with the Moyie River, downstream to Bonners Ferry and below Bonners Ferry to RM 141.4 (Meander Reach near Shorty's Island, a site of much of the documented egg deposition). Critical habitat is composed of parts or all of the Braided, Straight, and Meander Reaches (Figure 3-32). The primary constituent elements (PCEs)³² of white sturgeon critical habitat (73 FR 39505 2008), defined as the physical and biological factors essential to the conservation of the species that may require special management considerations and protection, are:

1. A flow regime, during the spawning season of May through June, that approximates natural variable conditions and is capable of producing depths of 23 ft (7 m) or greater when natural conditions (for example, weather patterns, water year) allow. The depths must occur at multiple sites throughout, but not uniformly within, the Kootenai River designated critical habitat.
2. A flow regime, during the spawning season of May through June, that approximates natural variable conditions and is capable of producing mean water column velocities of 3.3 ft/s (1.0 m/s) or greater when natural conditions (for example, weather patterns, water year) allow. The velocities must occur at multiple sites throughout, but not uniformly within, the Kootenai River designated critical habitat.
3. During the spawning season of May through June, water temperatures between 47.3°F and 53.6°F (8.5°C and 12°C), with no more than a 3.6°F (2.1°C) fluctuation in temperature within a 24-hour period, as measured at Bonners Ferry.
4. Submerged rocky substrates in approximately 5 continuous river miles (8 river kilometers) to provide for natural free embryo redistribution behavior and downstream movement.
5. A flow regime that limits sediment deposition and maintains appropriate rocky substrate and inter-gravel spaces for sturgeon egg adhesion, incubation, escape cover, and free embryo development.

Downlisting: For downlisting, Kootenai sturgeon should demonstrate consistent natural in-river production of juveniles, with production of wild age-3 juveniles occurring at an annual average of at least 700 individuals over 10 consecutive years. Production of 700 or more wild age-3 juveniles should occur in at least 3 of the 10 years, ensuring the annual average is not the result of an anomalous single-year event. For delisting, the number of Kootenai River white sturgeon wild recruits (offspring that survive to sexual maturity at 25 years) that are added to the adult (25 years or older) population annually should average at least 250 individuals per year over 10 years. In addition, the population should include at least 10,000 wild juveniles aged from 3 to 24 years" (USFWS 2019).

³² Note that PCEs have been replaced by the term *physical or biological features*, or PBFs, under the new regulatory definition of destruction or adverse modification of critical habitat (81 FR 7214, Feb. 11, 2016). In order to maintain consistency between this BA and prior documents in the consultation history, and because the change in terminology does not change the analysis, the PCE terminology is retained in this document.

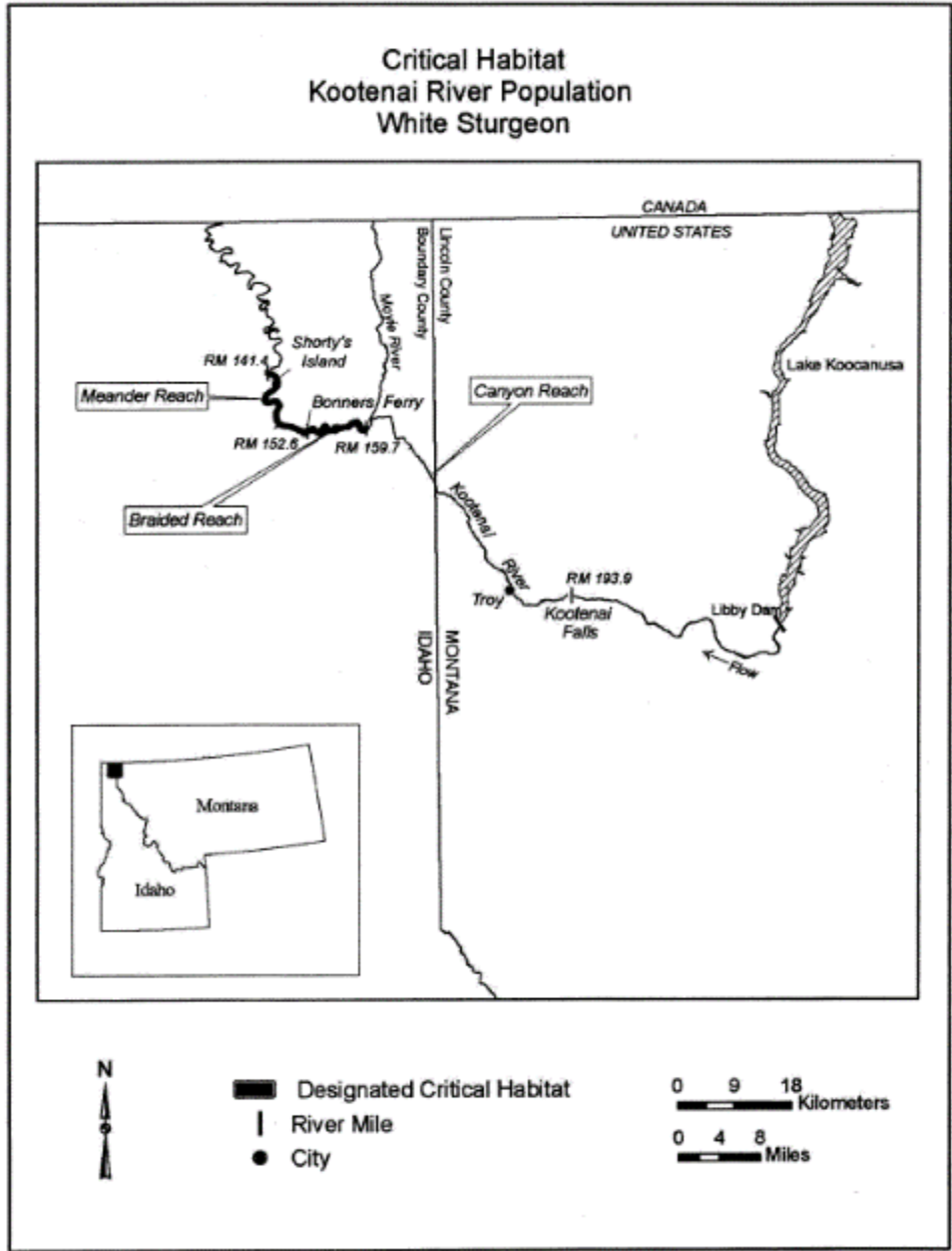


Figure 3-32. Designated critical habitat for Kootenai River white sturgeon (73 FR 39505)

DISTRIBUTION

Kootenai River white sturgeon occur in Idaho, Montana, and British Columbia, Canada, and are restricted to approximately 167.7 river miles of the Kootenai River system, extending from Kootenai Falls, Montana, located at RM 31 below Libby Dam, downstream through Kootenay Lake to Corra Linn Dam (at Bonnington Falls) at the outflow from Kootenay Lake in British Columbia. Approximately 45 percent of the species’ range is located in British Columbia.

Within the Action Area, the Kootenai River has been divided into four distinct reaches based on their unique geomorphic properties and sturgeon use: the Canyon Reach, Braided Reach, Straight Reach, and Meander Reach (Figure 3-33).

The Canyon Reach encompasses 59.1 river miles, extending from Libby Dam downstream to the confluence of the Moyie River at RM 160.9. Within this reach, the river is confined by bedrock, and the streambed has a steep gradient and is composed primarily of gravel and cobbles. Kootenai Falls is a natural barrier to fish migration.

The Braided Reach encompasses approximately 6.2 river miles (RM 160.9 to RM 152.7) from the Moyie River confluence downstream to the U.S. Highway 95 Bridge. Downstream from the confluence of the Moyie River, the Kootenai River enters a wider valley with decreasing gradient. Multi-channel, meandering, and riffle-pool characteristics are predominant in the Braided Reach, with gravel and cobble as the dominant channel substrate (KTOI 2009).

The Straight Reach encompasses 1.1 river miles (RM 152.7 to 151.7) from the U.S. Highway 95 Bridge in Bonners Ferry downstream to Ambush Rock. The reach is characterized by a constrained river corridor due to flood protection measures (i.e., levees) that are present along both banks through most of the reach, along with the U.S. Highway 95 bridge and train trestle revetments. Channel substrate transitions from gravel to sand through the reach (KTOI 2009).

The Meander Reach encompasses 45.2 river miles (RM 151.7 to RM 105.9) from the downstream extent of Ambush Rock to the United States-Canada border. This reach is situated in a low-gradient lacustrine valley, and channel substrates are dominated by sand and clay (KTOI 2009).

LIFE HISTORY

Sturgeon are large, fast-growing, long-lived, highly migratory benthic predators. They live to approximately 100 years, with females in the Kootenai River reaching reproductive maturity in their late twenties to early thirties. Sturgeon exhibit a potadromous life-history in which they spawn in the Kootenai River and use Kootenay Lake and adjacent reaches of the river for rearing.

Spawning occurs in May and June, ideally over coarse substrates in deep, turbulent, turbid, cool (46 to 57°F [7.8 to 13.9°C]), and high-velocity (3.3 ft/s [at least 1 m/s]) waters. Recent research suggests that sturgeon do not key in on a specific range of velocities; rather, they seek the highest velocity and depth within the spawning region for the given flow conditions that they are experiencing (Paragamian et al. 2009). These findings suggest that sturgeon will spawn in the best-perceived location, given the current environmental conditions and river regulations under dam operations (Paragamian et al. 2009). Even though the Braided and Canyon Reaches provide more suitable spawning substrates and velocities, spawning presently does not occur in these locations with any documented consistency (Paragamian et al. 2009). Instead, spawning currently occurs in the Meander and Straight Reaches over sand or silt substrates, which appears to be less conducive to egg attachment, hatching, and larval survival.

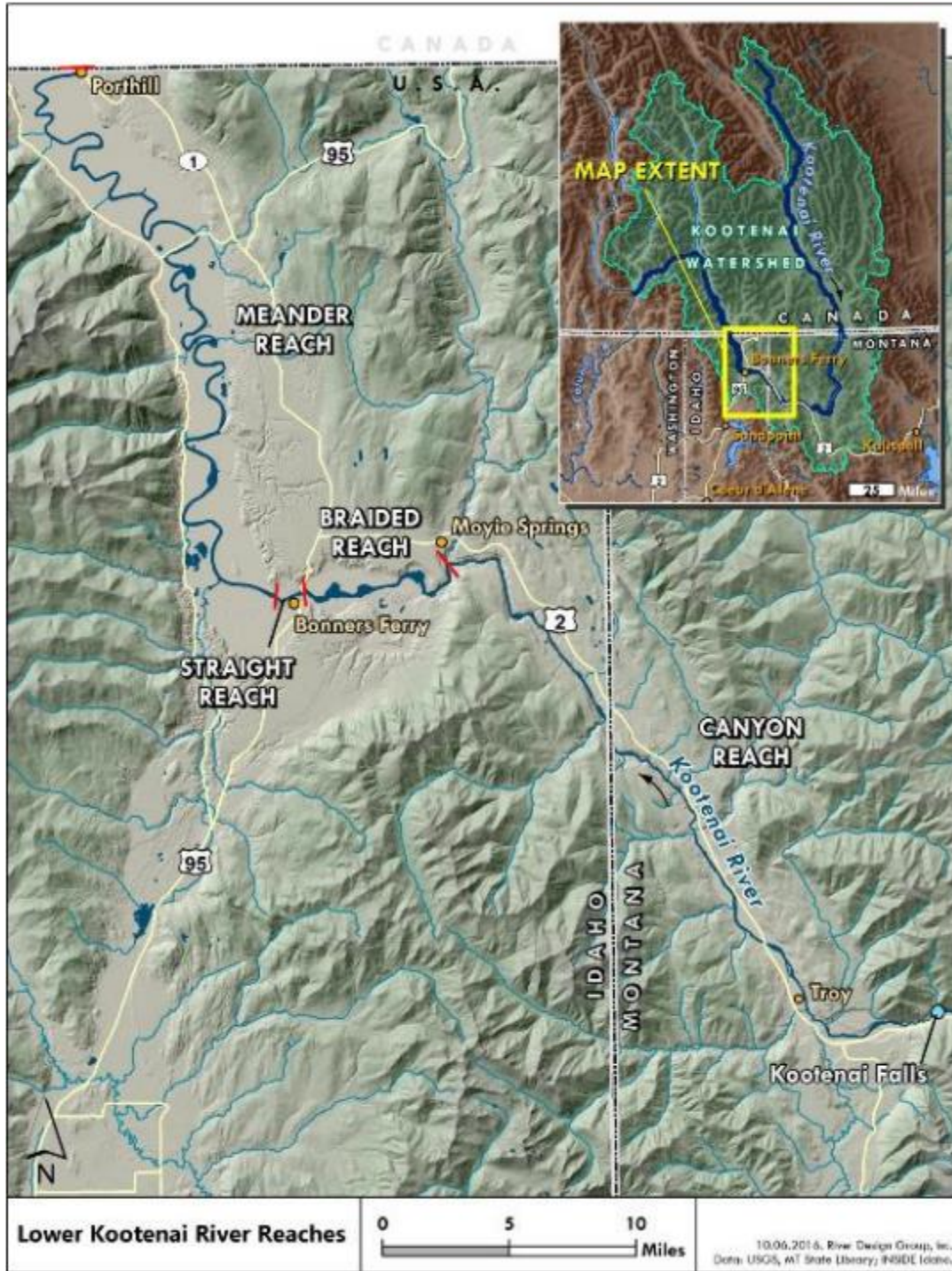


Figure 3-33. Lower Kootenai River Reaches in the Action Area

Kootenai sturgeon monitoring programs conducted from 1990 through 1995 revealed that during that 5-year period, sturgeon spawned within an 11.2 RM reach of the Kootenai River, from Bonners Ferry downstream to below Shorty’s Island (RM 143.0). Through 2018, most spawning continues to occur downstream of Bonners Ferry over sandy substrates; however, in 2018 IDFG documented the first-ever capture of a fertilized sturgeon egg upstream of Bonners Ferry over appropriate substrates in newly

constructed habitat. As river flow and stage increase, Kootenai sturgeon spawning tends to occur further upstream, near the gravel substrates that now occur at and upstream of Bonners Ferry (Paragamian et al. 1997; p. 30). Kootenai River white sturgeon exhibit a unique adaptation to cold water, with most spawning activity occurring near 50°F (10.0°C). They are also active at 43°F (6.1°C), which is several degrees cooler than water in which Columbia and Snake River white sturgeon are active (Paragamian et al. 2001; Flory 2011). Eggs incubate for 8 to 15 days, depending on water temperature (Brannon et al. 1985). Upon hatching, free embryos swim into the interstitial spaces in coarse substrates. If adequate cover is unavailable, the free embryos will swim up in the water column where they are passively redistributed downstream by the current. As their yolk sac depletes, free embryos develop into foraging larvae (10 to 12 days post-hatching). The foraging larvae initiate downstream dispersal and are no longer dependent upon rocky substrate or high-water velocity for survival. Downstream dispersal peaks at 14 days after hatching (Flory 2011). Larval sturgeon require an additional 20 to 30 days to metamorphose into juveniles.

Larvae and juveniles move gradually downstream into Kootenay Lake and low-gradient areas of the river along shorelines, and in inundated riparian areas and floodplains in complex habitats with wood and emergent vegetation. Adults feed in deep benthic habitats in Kootenay Lake and the Kootenai River and migrate to spawning areas in late spring. Juveniles, sub-adults, and adults have been observed in mixed aggregations on the bottom of the Kootenai River (Golder and Associates, undated video).

PREY

Sturgeon in the Kootenai River system and elsewhere are considered opportunistic feeders, with sturgeon more than 28 inches (70 cm) in length feeding on a variety of vertebrate and invertebrate prey items including clams, snails, aquatic insects, and fish. Kokanee (*O. nerka*) in Kootenay Lake, prior to a population crash beginning in the mid-1970s, were once considered an important prey item for adult white sturgeon (USFWS 1999).

POPULATION DYNAMICS

Little information is available on the sturgeon population prior to the completion of Libby Dam in 1972. Approximately 8,000 sturgeon are estimated to have been present in the Kootenai River system in the late 1970s (Paragamian et al. 2005). Based on mark-recapture data collected between 1980 and 2000, the wild population was projected to be 270, with an annual mortality rate of 9 percent by 2011 (Paragamian et al. 2005). After the collection and analysis of 10 additional years of mark-recapture data and use of a model that was deemed to provide more appropriate estimates of population parameters, Beamesderfer et al. (2014) found the wild sturgeon population to be larger than previously projected. Beamesderfer et al. (2014) estimated that the natural sturgeon population declined from approximately 3,000 individuals in 1990 to 990 in 2011. “In 2019, an interim progress report from Idaho Department of Fish and Game (IDFG) estimated that the wild adult Kootenai sturgeon population abundance had declined from approximately 2,072 individuals in 2011 to 1,744 individuals (confidence interval 1,232 to 2,182) in 2017 (Hardy and McDonnell 2019). Annual survival rates (estimated by mark-recapture analysis) are estimated to be approximately 96 percent. These latest estimates are the most current information available and constitute the best available science on the abundance and survival of wild adult Kootenai sturgeon” (USFWS 2019).

The current natural population largely consists of an aging cohort of large, old fish. The wild sturgeon population currently averages approximately 63.0 inches (160 cm) fork length (FL), and the majority of fish are 43.3 inches (110 cm) FL or longer (Beamesderfer et al. 2014). While the estimated average annual mortality rates for wild fish are now estimated to be 1 to 4 percent, lower than the previous 9 percent estimate, this mortality rate may be increasing as the wild fish continue to age. The wild population was found to decline most rapidly from 2008 to 2011 due to decreased survival rates (97 percent annual survival prior to 2008 and 85 percent from 2007 to 2011), presumably due to increased adult age.

Low levels of natural recruitment continue to be documented based on low sample numbers of juvenile fish; Beamesderfer et al. (2014) estimated natural recruitment to the wild population of 13 fish per year. Natural reproduction at this level cannot be expected to provide any population level benefits (Anders et al. 2014), nor would reproduction at this level have been adequate to sustain the population of 6,000 to 8,000 sturgeon estimated to exist in 1980 (Anders et al. 2014). The last year of significant natural recruitment was 1974. Figure 3-34 shows that multiple juvenile age classes of natural fish are present and have been captured in Idaho between 1977 and 2016.

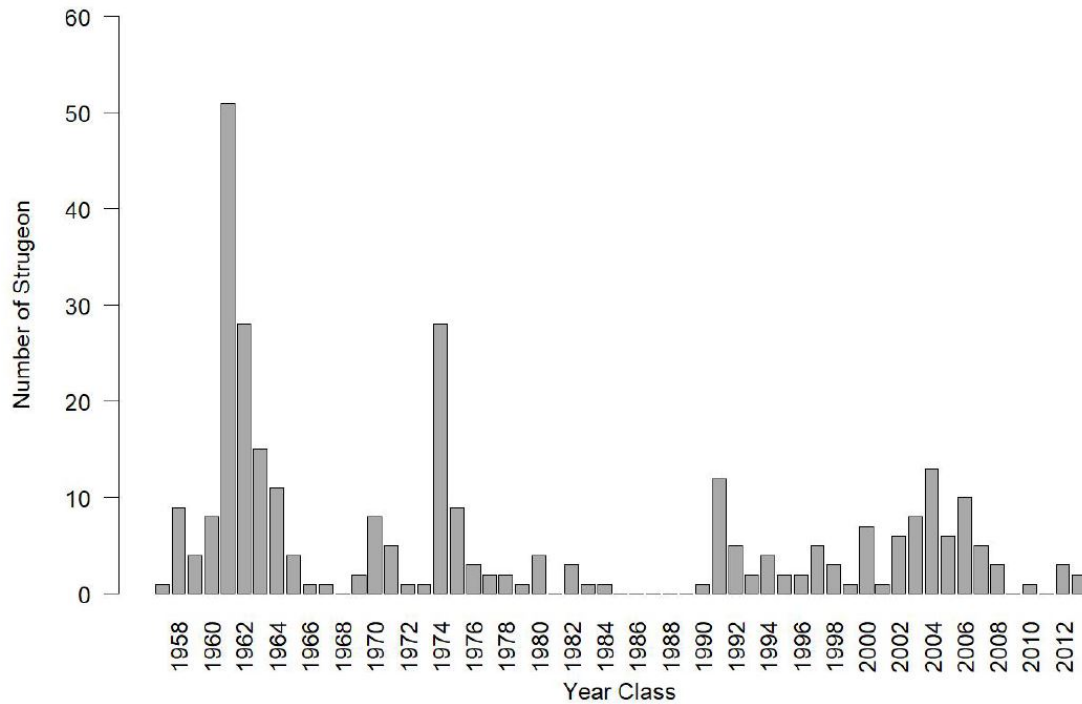


Figure 3-34. Total number of wild juvenile white sturgeon by age class captured in the Kootenai River, Idaho, between 1957 and 2014. [Source: Ross et al. (2018)].

Current projected population trends for wild sturgeon vary depending on the model used (Beamesderfer et al. 2014). Under the most pessimistic projection using the 2011 survival rate of 71 percent (Model 4), the wild population was projected to decline to fewer than 100 fish by 2018. This wild population projection increases to approximately 300 individuals by 2018 when using the 2007 to 2011 4-year average survival rate of 85 percent. The most optimistic projection (Model 2) that uses the pre-2007

annual survival rate of 98 percent estimates that 1,300 natural sturgeon would be present in 2030 (Beamesderfer et al. (2014); Figure 3-35).

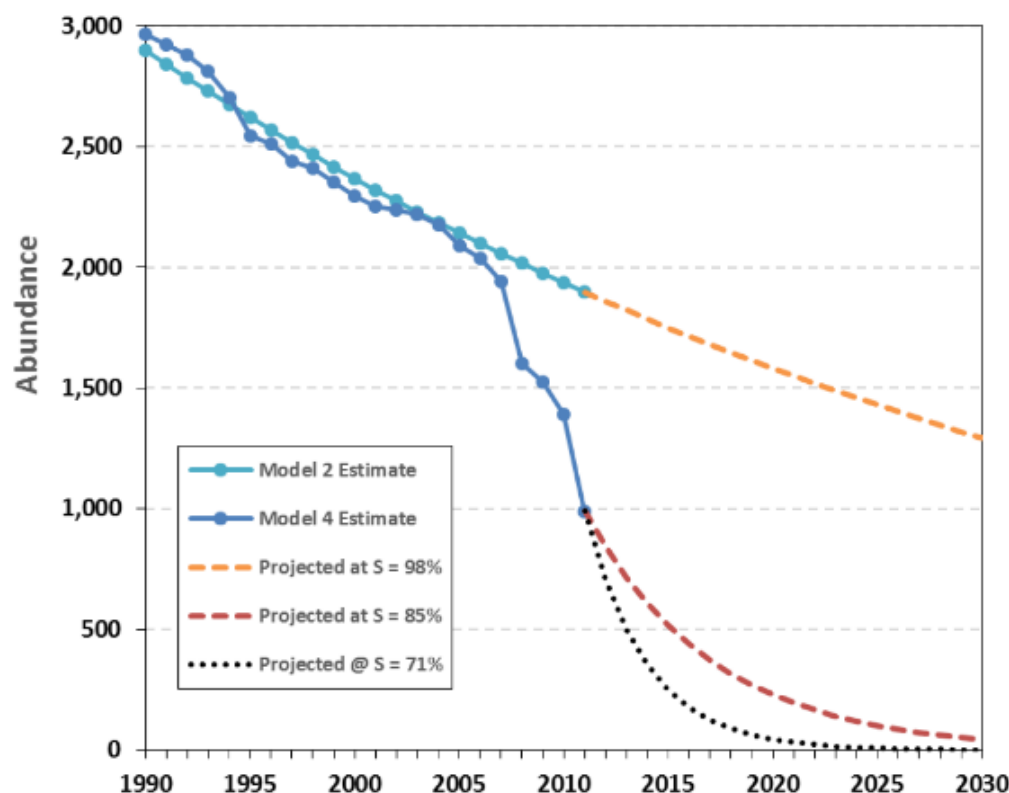


Figure 3-35. Projected future abundance of wild Kootenai white sturgeon based on alternative models and assumptions regarding current abundance and future survival (S), with a hind-casted population abundance estimate based on 98 percent adult survival. [Source: Beamesderfer et al. (2014)].

While current and projected natural population levels are higher than previously estimated, the wild population is still in decline, due to an aging population and continued recruitment failure, and the hatchery program continues to be crucial for the longevity of the species. From 1992 through 2012, a total of 222,708 juvenile hatchery sturgeon were released into the Kootenai River system.

Juveniles are released at approximately 1.5 years of age from the Kootenai Tribal Sturgeon Hatchery and Twin Rivers Hatchery in Bonners Ferry, Idaho, in the spring. Mark-recapture analyses estimate that in the first year following release, survival of fish released at age 1 is 20 percent on average; for fish released at age 2, it is 80 percent; and for fish released at age 3 and older, it is 93 percent (R. Hardy, IDFG, personal communication). First-year survival is strongly related to size at release, with larger fish surviving at a much higher rate than smaller fish. As of 2014, 12,000 to 15,000 juvenile hatchery fish from multiple hatchery year classes are estimated to have survived (Dinsmore et al. 2015). Hatchery-produced fish have not yet reached reproductive age; therefore, natural recruitment as a result of the hatchery fish releases cannot be determined. Figure 3-36 shows the estimated number of hatchery fish present in the system by age class. Multiple release years (and associated age classes) are represented in the current hatchery-produced population estimates.

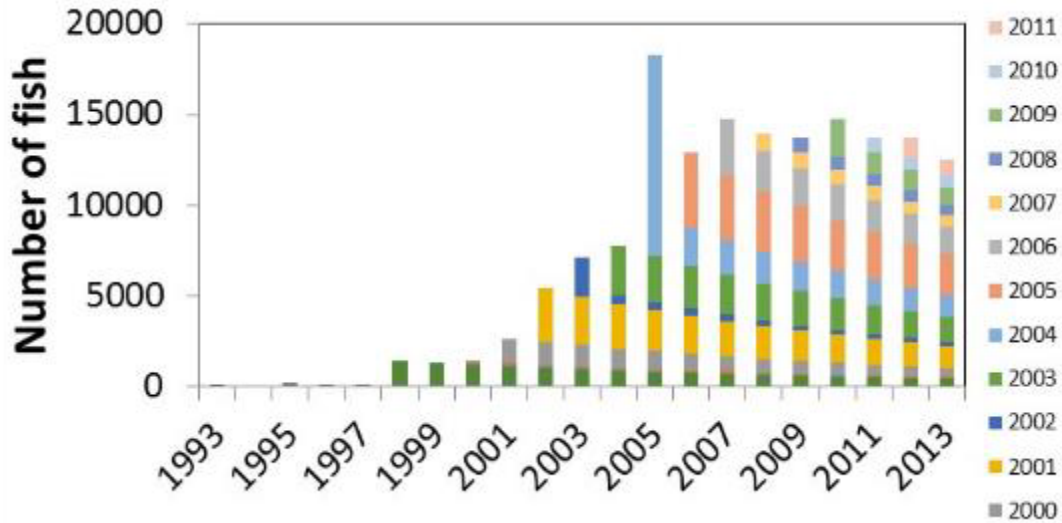


Figure 3-36. Estimated annual numbers of Kootenai sturgeon (of all age classes, by release year) for the Kootenai River subbasin. [Source: Dinsmore et al. (2015)].

3.3.2.2 Factors Affecting the Status of Kootenai River White Sturgeon

The wild sturgeon population comprises mainly old adults, and significant recruitment has not occurred since the 1970s. Although the specific causes of recruitment failure remain unclear, years of study suggest that most mortality occurs between the egg and larval stages. Despite years of intensive sampling only one fertilized egg, very few larva, and relatively few wild juveniles have been collected (Rust et al. 2014). Recruitment and survival of sturgeon are affected by various threats, some related to and others independent of Libby Dam operation. Dam existence and operation have caused or contributed to water temperature alterations, decreased spawning habitat suitability, decreased floodplain rearing habitat, and increased potential for predation on early life stages (Kock et al. 2006).

During the late 1800s and early 1900s, efforts began to convert the land along the Kootenai River floodplain to facilitate settlement and agriculture (Kootenai Tribe of Idaho and Montana Fish 2004). Loss and disconnection of riparian upland and wetland habitats and the natural floodplain that began in the 1880s with land conversion was further supported through the use of extensive dikes built along the river, primarily between the 1920s and 1950s (Richards 1997). The diking helped to provide flood protection to the converted land uses. The land conversion and diking has contributed to a lack of riparian and wetland function and off-channel habitat diversity. An overall decrease in productivity in the Kootenai River and in Kootenay Lake has resulted from a decrease in floodplain interaction. The land conversion and diking of the Kootenai River near Bonners Ferry resulted in a loss of about 50,000 acres of natural floodplain (Richards 1997). Floodplain conversion to agriculture is most prominent in the Meander Reach but has occurred throughout all reaches (Kootenai Tribe of Idaho and Montana Fish 2004).

The onset of operations at Libby Dam resulted in lower average spring peak flows and increased winter flows in the Kootenai River. Before experimental flow augmentations began in 1991 (Paragamian et al. 2001), the natural high spring flows thought to be required by sturgeon for reproduction and transport of juveniles rarely occurred during the May-to-July spawning period when appropriate temperature,

water velocity, and photoperiod conditions would normally exist. Historical pre-dam discharges during sturgeon spawning varied from approximately 50,000 to 100,000 cfs at Bonners Ferry. Libby Dam peak discharge is ~25,000 cfs, though discharge as high as about 48,000 cfs during spring due to FRM operations, and 35,000 cfs for sturgeon BiOp-related flow enhancements over powerhouse capacity. The dam creates a more predictable hydrograph by decreasing the frequency of extreme flow events; however, the consequences of stability are habitat simplification, altered sediment transport, lower productivity, and modified thermal and nutrient regimes (Paragamian 2012; USFWS 1999a).

Pre-dam water temperatures were slightly warmer in the summer and cooler in the winter compared to post-dam temperatures [Partridge (1983) as cited in Paragamian (2012)]. Decreased spring water temperatures in the Kootenai River below Libby Dam are a result of the thermoregulating properties of Lake Kootenai; the thermal mass of the reservoir is slower to warm during spring than the free-flowing river had been. Growth of larval and juvenile sturgeon is slowed by decreased water temperatures and, combined with other factors, may result in reduced survival of sturgeon through early life stages (USFWS 1999).

Water in Lake Kootenai stores heat over the summer and fall, creating a slight increase in winter water temperatures downstream of Libby Dam. This increase in winter water temperatures may increase bioenergetic demands at a time of low food availability, which may affect survivability due to the increased starvation risk for juvenile sturgeon. Higher seasonal water temperatures have been shown to alter bioenergetic requirements and may stress fish, thereby impacting reproductive condition and increasing the risk of disease outbreak (Hatfield et al. 2004). As discussed further in Chapter 2, downstream water temperatures are managed when the reservoir is stratified, but downstream water temperatures cannot be managed through operation during the winter after the water becomes isothermic (i.e., the same temperature near the surface and bottom of the lake).

Human activities have caused losses in riparian and wetland areas or substantially impaired riparian, wetland, and overall floodplain functions along the lower Kootenai River since the early 1900s (KTOI 2009). Habitat and water quality impacts in the Kootenai River stemming from these conversion activities include water impoundments and diversion; river diking, flood control and channelization; wetland draining and associated reduction of native species dependent on wetlands (including beavers); livestock grazing; urban and suburban development; land clearing for agriculture; road building; and recreation. This degradation has impaired key riparian and floodplain wetland ecological functions, including sediment filtering, streambank building, water storage, aquifer recharge, dissipation of stream energy, nutrient retention, and fish and wildlife habitat. Diking in the floodplain has affected the natural flow regime of the tributaries that join the Kootenai River in the Kootenai River valley (USFWS 2002b).

Timber harvest activities (harvest, timber roads, etc.) occur on private and federally managed lands in tributary watersheds, such as the Fisher River. The timber harvest activities increase sediment loading in the tributaries, which can wash into the mainstem Kootenai River. Suspended sediments due to logging, road runoff, and other land-management activities are a major source of turbid conditions in the Kootenai River during snowmelt. Elevated tributary-derived suspended sediment, combined with the altered hydrology of the Kootenai River, has resulted in the formation of deltas from deposition of bedload materials (sand, gravel, and boulders) at the confluence of some tributaries to the Kootenai River (Marotz et al. 1998).

Aquatic habitat within reaches of the Kootenai River downstream of Libby Dam has been adversely affected by dam operations since construction and operation of the Libby Dam Project in 1972 (USFWS 2006). Following construction, the Kootenai River has experienced changes in the natural hydrograph and seasonal temperature regime (Rust et al. 2014). The long-term management of Kootenai River surface water for FRM and reservoir recreation, combined with other anthropogenic floodplain and in-channel perturbations, have left the lower Kootenai River and its floodplain with highly altered aquatic habitat (USFWS 2006). Spring flow peaks have been reduced to about one-third of maximum pre-dam levels, and flows during winter are now three to four times higher than under a natural flow regime. Post-dam water temperatures are now cooler in summer and warmer in winter than prior to construction and operation of Libby Dam (Rust et al. 2014).

Decreased spawning habitat suitability has resulted in some locations from the altered seasonal hydrograph below Libby Dam. Ideal spawning habitat is characterized by high velocity, high turbidity, and high turbulence. The reduction of peak flows in the spring has resulted in degradation of physical spawning conditions in portions of the river. However, suitable spawning substrate is generally believed to exist in the Braided and Canyon Reaches.

Under the 2006 USFWS BiOp, operations of Libby Dam were altered to provide higher, more stable summer discharges to the extent possible to meet sturgeon and bull trout ESA responsibilities and to mimic a more natural river hydrograph (under VARQ FRM regime). The intent was also to provide spawning and incubation flows to meet targets for water depth and velocity, along with managing the selective withdrawal system at Libby Dam to provide more suitable temperature in the Kootenai River. Adequate flows and temperature encourage spawning sturgeon to migrate upstream of Bonners Ferry into and through the Braided Reach to more suitable spawning habitat. Hydrographs for the Kootenai River at Libby Dam and Bonners Ferry for multiple timeframes are presented in Chapter 2.

Increased predation on early life stages of sturgeon has resulted from the attenuation of high-flow events and reduced turbidity, allowing for predatory fish that would otherwise be deterred by seasonal high flows and lower visibility to feed on eggs, larvae, and juvenile sturgeon. These conditions may also be conducive to denser populations of predatory fish.

Additional threats unrelated to Libby Dam operation include potential water quality impairment from other human activities such as ongoing agriculture, mining, logging, and road construction in the watershed, and inadvertent harvest or poaching (USFWS 1999).

Poor water quality was a major problem for sturgeon and other native fish prior to the construction of Libby Dam. Pollution associated with industrial and mine development has been thought to affect sturgeon reproduction and recruitment prior to 1974. Pesticides, polychlorinated biphenyls, and metals, such as copper, aluminum, lead, strontium, and zinc, have been detected in eggs; all, except copper, are at lower levels than in other Columbia River Basin areas where sturgeon successfully reproduce (USFWS 1999). Elevated levels of selenium have been detected in the Elk River in Canada, a tributary to Lake Kootenai; increased selenium levels are correlated with waste rock volume from coal mining (G. Hoyle, KTOI, pers. comm., 2015). Selenium loading has been increasing as waste rock volume increases, and elevated levels have also been detected in Lake Kootenai and at the Libby Dam tailwater (K. Easthouse, Corps, Seattle District, pers. comm., 2015). Kootenai River white sturgeon eggs have been hatched under experimental hatchery conditions using both Kootenai River water and domestic city

water, but the chronic effects of heavy metals on egg hatching success and the dietary pathways of larvae and young-of-the-year white sturgeon have not been investigated. The overall effects of pollutants on sturgeon are unknown (USFWS 1999).

Burbot in the Kootenai River and in Kootenay Lake are fished for using methods that are conducive to sturgeon capture, and the potential exists for sturgeon to be illegally harvested during the burbot fishery. Poaching threatens sturgeon population numbers as well (USFWS 1999).

3.3.2.3 Climate Change and Sturgeon

Research for the larger Northern Rockies area predicts warmer springs, earlier snowmelt, and hotter, drier summers with longer fire seasons in the future (USGCRP 2017). These future climate change scenarios, particularly earlier snowmelt and changes in precipitation patterns, would alter inflows and water temperatures in rivers in the Action Area, as well as altering the thermal characteristics related to modified seasonal volume and mixing within the reservoirs. There is still a great deal of uncertainty associated with predictions relative to the timing, location, and magnitude of future climate change. Anthropogenic contributions to climate change occur at a global scale, so it is challenging, if not impossible, to accurately quantify the human-caused contribution of private, state, tribal, and local non-federal actions on the regional climate as a result of activities within the Action Area. As described in the Factors Affecting the Kootenai River White Sturgeon section above, lower-than-normal water temperatures in the spawning reach may affect spawning behavior, location, and timing. Preferred spawning temperature for the Kootenai sturgeon is near 50°F; impacts of climate change may not be great for the sturgeon, since they are not reliant on very cold water for reproduction.

3.3.2.4 Environmental Conditions for Sturgeon in the Action Area

3.3.2.5 Kootenai River White Sturgeon Critical Habitat

Since the last consultation, Libby Dam has been operated consistent with the 2006 and 2008 RPAs to meet sturgeon critical habitat PCEs, except for the 23-foot (7-meter) depth criterion over rocky substrate in the Braided Reach, which would require exceedance of the 1,764-foot flood stage at Bonners Ferry. Under various habitat improvement projects already completed, multiple deep pools have been excavated to increase depth, which is expected to help address the depth criterion during future sturgeon spawning seasons.

Despite ongoing measures to benefit sturgeon in the form of experimental discharge and increasingly improved riverine conditions for meeting PCEs, natural production has not yet been restored, and wild sturgeon general migration or known spawning behaviors have not changed (Anders et al. 2014). It is not currently known why wild fish have not exhibited a significant positive response to management actions implemented to date (Flory 2011). In addition, it is too soon to determine whether the deep pools or other habitat improvement projects will encourage wild sturgeon to migrate farther upstream to spawn in the Braided and Canyon Reach, or whether sexually mature, hatchery-produced sturgeon will exhibit different migration and spawning behaviors than wild sturgeon; however, steady to increasing proportions of spawning fish have exhibited migration patterns farther upstream since the

KTOI-led habitat enhancement projects upstream of Bonners Ferry commenced in 2011 (G. Hoffman, Corps, pers. comm., 2019).

Baseline conditions for each PCE for sturgeon critical habitat are described here as follows:

PCE 1: A flow regime, during the spawning season of May through June, that approximates natural variable conditions and is capable of producing depths of 23 ft (7 m) or greater when natural conditions (e.g., weather patterns, water year) allow. The depths must occur at multiple sites throughout, but not uniformly within, the Kootenai River designated critical habitat.

Outside of restoration project areas, the 23-foot- (7-meter) minimum depth has largely not yet been met in the Braided Reach, where suitable rocky substrate is available, in part because achieving this depth under current conditions would require exceedance of the 1,764-foot river flood stage at Bonners Ferry. The Upper and Middle Meander Projects completed in the Braided Reach resulted in the creation of deep pools through excavation and the installation of pool-forming structures designed to provide sturgeon pool habitat and to help meet the sturgeon depth criteria. The Bonners Ferry Island and Straight Reach habitat improvement projects excavated large pools to increase depth and installed pool-forming structures, which are expected to further address the depth criterion during future sturgeon spawning seasons. The completion of the Bonners Ferry Island and Straight Reach projects, combined with the previous restoration projects that involved pool formation, have provided contiguous availability of deep pools within the Meander Reach, Straight Reach, and Braided Reach, though the Meander Reach does not feature substantial presence of suitable rocky substrate for spawning and incubation despite featuring suitable depth.

The 2015 Action Agencies' annual report for 2014 activities in response to the 2006 BiOp stated that,

Intermittent depths of 16.5 feet [5 m] or greater over 60 percent of the rocky thalweg line from RM 152-157 were observed during 16 days of the peak augmentation flow period (16 May through 9 June); the range of coverage of the 16.5 feet [5 m] depth attribute criterion over rocky substrates was 47-83 percent during peak augmentation flows. Intermittent depths of 23 feet [7 m] or greater over 60 percent of the rocky thalweg line from RM 152-157 were observed during 0 days of the peak augmentation flow period (16 May through 9 June); the range of coverage of the 23.0 feet [7 m] depth attribute attainment criterion over rocky substrates was 15-36 percent during peak augmentation flows.

These results were similar to those observed in other years, and vary with Kootenay Lake backwater extent, tributary inflow, and timing and volume of Libby Dam discharge ("tiered flow"); the Action Agencies discontinued calculation of proportion of depth attribute achievement in 2016 after 10 years (2006–2015), as the 23 foot criterion is not achievable within flood stage (1764') despite habitat modifications that have provided functional depth for the purposes of this PCE.

PCE 2: A flow regime, during the spawning season of May through June, that approximates natural variable conditions and is capable of producing mean water column velocities of 3.3 ft/s (1.0 m/s) or greater when natural conditions (for example, weather patterns, water year) allow. The velocities must occur at multiple sites throughout, but not uniformly within, the Kootenai River designated critical habitat.

According to simulation results of Barton et al. (2010a), minimum velocities of 3.3 ft/s were met along the length of the Braided Reach nearly consistently during the 2006–2009 spawning seasons. Based on their analysis, the velocity criterion was also met in some or all of the length of the Straight Reach. The velocity criterion cannot be reached in the Meander Reach, even with the 2006 (and other) high flows, due to backwater effects associated with Kootenay Lake and the flow constraints imposed by other project purposes.

The 2015 Action Agencies' annual report for 2014 activities in response to the 2006 BiOp said,

Velocity met or exceeded 3.3 ft/s in 55-59 percent of rocky substrate from RM 152-157 during all days of the post-peak augmentation flows (10 June through 18 June).

Results were similar to those observed in other years, varying with Kootenay Lake backwater extent, tributary inflow, and timing and volume of Libby Dam discharge ("tiered flow"); the Action Agencies discontinued calculation of proportion of velocity attribute achievement in 2016 after 10 years (2006–2015), as the velocity criterion is met in most years, particularly in the Braided Reach, as discussed above.

PCE 3. During the spawning season of May through June, water temperatures between 47.3°F and 53.6°F (8.5°C and 12°C), with no more than a 3.6°F (2.1°C) fluctuation in temperature within a 24-hour period, as measured at Bonners Ferry.

With few exceptions, this criterion has been consistently met throughout May and June of 2006–2019 (G. Hoffman, Corps, pers. comm., 2019).

PCE 4. Submerged rocky substrates in approximately 5 continuous river miles (8 river km) to provide for natural free embryo redistribution behavior and downstream movement.

The substrate in the 7-mile-long Braided Reach portion of designated sturgeon critical habitat is largely rocky (gravel and cobble). In the Straight Reach, there are gravel and bedrock over a large percentage of the substrate (Barton et al. 2010). The Meander Reach flows through glacial lacustrine substrates and is largely characterized by sand and fine sediments, with outcroppings of clay and a few small areas of exposed gravel near tributary mouths. Large cobble and rocks have been placed over short distances in the Meander Reach as part of two habitat restoration project pilot studies near Shorty's Island and Myrtle Creek (current sturgeon spawning locations).

PCE 5. A flow regime that limits sediment deposition and maintains appropriate rocky substrate and inter-gravel spaces for sturgeon egg adhesion, incubation, escape cover, and free embryo development.

Libby Dam flow releases for sturgeon since 2006 have provided velocities sufficient to maintain exposed gravel and cobble in the Braided Reach and exposure of gravel and bedrock in the Straight Reach.

3.3.2.6 Effects of the Proposed Action on Kootenai River White Sturgeon

Under the Proposed Action, the Action Agencies will implement adaptive management principles using measures to improve sturgeon reproduction and recruitment as a component of operating and maintaining Libby Dam in a manner that is consistent with its multiple authorized purposes.

EFFECTS ON THE SPECIES

Direct and indirect effects to sturgeon from dam operations and maintenance, including operational measures to benefit listed species and designated critical habitat, and the Bonneville-funded actions in the Kootenai River (nutrients, habitat, hatchery, and RM&E) are discussed below. Under the Proposed Action, the Action Agencies will continue to manage Libby Dam in support of the functional adaptive river concept and to implement adaptive management flow experiments to further investigate sturgeon life history requirements in the Kootenai River. Fish protection and recovery measures, namely flow and temperature management, directed at contributing to the protection of sturgeon are described below as conservation measures intended to eliminate or reduce adverse effects of the Proposed Action.

Libby Dam Operations and Maintenance

Libby Dam will continue to be operated to meet VARQ FRM procedures, and the Action Agencies will continue to adaptively manage spring operations of Libby Dam. The pre-season work performed by the FPIP Technical Team and ongoing adaptive management throughout the season will ensure that springtime flow, velocity, and temperatures are maintained in a manner believed consistent with sturgeon requirements for spawning and incubation. Adaptive management actions will continue to pursue the ongoing goal of encouraging sturgeon to use the rocky substrate in the Braided Reach (and to potentially migrate into the Canyon Reach) for spawning.

As sturgeon are not known to inhabit Lake Koocanusa, there are no effects on sturgeon from changes in reservoir habitat conditions. Thus, VARQ FRM, variable end-of-December draft, reservoir refill, and summer draft for salmon, as they affect reservoir elevations, do not affect Kootenai River white sturgeon.

Effects of dam operation and flow management on sturgeon downstream of the dam are discussed below.

Water Velocity and Flows

River velocity and flows downstream of Libby Dam are affected by dam operations and Kootenay Lake elevations, among other factors such as channel slope, width, and depth. With implementation of sturgeon flow augmentation, suitable spawning habitat is being provided in the Braided Reach where substrate is clean gravel and cobble, and water velocities are greater than 3.3 ft/s (1.0 m/s). This water velocity target will ensure that any spawned eggs are dispersed, thus minimizing the potential for predation. Although the Braided Reach provides the most appropriate spawning substrates, wild adult sturgeon have continued to spawn over sandy or otherwise inappropriate substrates, such as those in the Meander Reach. This behavior is likely contributing to the low survival rate of eggs to larvae to juveniles. To date, the sturgeon flow augmentations have not yet been successful in reestablishing wild spawning in the Braided and Canyon Reaches, though IDFG captured the first-ever wild-spawned fertilized sturgeon egg in the Braided Reach during flow augmentation operations in 2018. However, it is too soon to know whether hatchery-produced sturgeon will use the more appropriate upstream habitat for spawning when they reach sexual maturity (starting in 2020) or as restoration work designed to improve migration corridor habitat is completed. The hatchery population, including those fish

remaining in the Canyon Reach in Montana, that will soon reach maturity, combined with the completion of habitat restoration projects (such as the excavation of deep pools) and spring sturgeon flows from Libby Dam, may result in future spawning in locations more conducive to natural sturgeon recruitment.

Implementation of bull trout and salmon flows will not be expected to measurably affect sturgeon. Minimum flows in May and June (6,000 cfs for bull trout) are well below the proposed sturgeon flows for the same months. Summer and fall flows for bull trout minimums, salmon outmigration, and FRM drafting may not have a substantial direct effect on sturgeon. While summer and fall flow levels are higher than historically present in the system, sturgeon evolved with higher and longer spring flow periods. There will be no effect on sturgeon downstream in Kootenay Lake from these operations.

It is possible that full powerhouse flow or an involuntary spill event could occur during the spring as part of VARQ FRM operations. Non-test spill events occurred in 2 (2006 and 2013) of the last 12 years. While that is not infrequent, it is not anticipated that these involuntary spills will occur on a yearly basis. VARQ FRM has been implemented adaptively so as to reduce the likelihood of early filling and involuntary spill. If spill does occur during the spring months, this will result in increased water velocity, depending on the backwater stage from Kootenay Lake. However, because sturgeon evolved with spring flows that were historically much higher than present averages, the increased velocity will not be expected to negatively affect sturgeon and will provide a benefit.

Maintenance (especially unscheduled maintenance) that requires one or more generating units to go offline may reduce river flows if no spill is provided to make up the difference. Depending on the season, this in turn may result in slower velocities and reduced depth in the Braided Reach, and thus potentially affect sturgeon spawning in the event of spawner activity there. As flow and velocity are not linearly correlated, the effects of decreased flow under this scenario may vary in this reach, depending on the portion of the channel (i.e., thalweg vs. margin), level of flow decrease, tributary inflows, and other factors. Typically, during the spawning season, Kootenay Lake backwater effects influence velocities in the Straight and Meander Reaches; thus, decreased flow may have a variable, if any, effect on velocities in these reaches.

Water Quality

The Action Agencies' approach to flow management emulates normative temperature and flow relationships and provides a peak spawning window as flow is receding and temperature is increasing. Spring and summer water releases will continue to be managed to provide steady temperatures, avoiding a sudden drop of more than 3.6°F (2°C) at Libby Dam during incubation, hatching, and larval development. Target temperatures at Bonners Ferry are a 50°F (10.0°C) minimum during sturgeon spawning, with an increase to pre-dam normative temperatures in July and August to support larval development. The spring and summer temperature regime under the Proposed Action is within acceptable spawning and rearing temperatures for sturgeon; therefore, continued operation of Libby Dam should benefit sturgeon during their critical spawning and rearing period.

Should spill occur in the spring months involving the sluiceways (regulating outlets), the introduction of cooler water into the river could lower water temperature (and produce TDG levels more deleterious than spillway discharge), leading to a delay in migration and spawning activities (Paragamian and

Wakkinen 2011). It is unlikely the sluiceways will be used during sturgeon spawning, since the reservoir will be high enough to use the spillways, through which warmer water will be released.

Temperature stratification in Lake Koocanusa breaks down in late fall and winter; it is not possible to control temperature in dam releases once that happens. Stored heat in the reservoir means winter release temperatures are warmer than pre-dam. Winter is a time of low food availability, metabolism, and feeding activity. Warmer-than-normal winter temperatures may increase metabolic rates of juvenile sturgeon and thus feeding activity, in turn increasing risk of starvation.

Nutrients are trapped to a great extent in Lake Koocanusa (63 percent of total phosphorus, 25 percent of total nitrogen), making the downstream river environment nutrient-poor. This has been the impetus for nutrient additions via an automatically metered system at the Idaho/Montana line in the Canyon Reach, which provides phosphorus input during the productive months, and may also provide nitrogen if needed.

Elevated turbidity, which often is observed with spring snowmelt runoff, is believed to limit predation on sturgeon eggs and larvae by sight-feeding predators. Libby Dam operations will continue to limit the phytoplankton component of turbidity, and thus maintain conditions that contribute to predation on sturgeon eggs and larvae.

Effects of elevated TDG from spill that does occur at Libby Dam will be observed upriver of Kootenai Falls, which normally resets gas saturations to about 118 percent; substantial off-gassing occurs at Canoe Gulch, a series of rapids approximately four miles downstream of Libby Dam. Since sturgeon have been found only downriver of the falls, there is expected to be no effect to sturgeon from elevated TDG coming out of Libby Dam.

Depth

The 23-foot criterion is not achievable within flood stage (1764') despite habitat modifications that have provided functional depth for the species, and the Action Agencies discontinued calculation of proportion of depth attribute achievement in 2016 after 10 years (2006–2015) of monitoring.

Continuing to not meet this depth criterion could fragment or limit the duration of adult sturgeons' access to their preferred spawning habitat. This may be why wild adult sturgeon have continued to spawn in the Meander Reach, where incubation and early rearing habitat is limited, rather than in the Braided Reach and Canyon Reach, where spawning substrate and rearing habitat are more appropriate. However, it is not completely certain what is inhibiting sturgeon from spawning in the Braided Reach, since they have been shown to migrate into these reaches for at least short times.

Maintenance (especially unscheduled maintenance) that requires one or more generating units to go offline may reduce river flows if no spill is provided to make up the difference. This, in turn, may affect depths in the Braided Reach, and thus potentially affect sturgeon spawning in the event of spawner activity there.

Conservation Aquaculture

Nutrient Addition

Due to the effects of Libby Dam on downstream nutrient budgets, Bonneville has supported nutrient supplementation programs in the South Arm of Kootenay Lake and the Kootenai River since 2004 and 2005, respectively.

Under the Proposed Action, nutrient enhancement in the South Arm of Kootenay Lake will continue. These efforts will maintain or increase food web productivity and benefit native fish, zooplankton, and macroinvertebrate populations, which are preyed on by juvenile sturgeon, and kokanee salmon, which are an important food item for both adult and juvenile sturgeon. Results from the first 9 years of the nutrient supplementation program indicate that the actions are providing a positive change and increasing productivity in Kootenay Lake, which is inhabited by sturgeon juveniles and adults. The beneficial increase in productivity in Kootenay Lake is expected to continue as the program continues and is adaptively managed over the next 5 years.

Nutrient supplementation may also continue in the Kootenai River. Results from monitoring indicate that while the program is providing a positive change, particularly in the Canyon Reach, Kootenai River nutrient additions have not resulted in apparent increased production in the Meander Reach, where most juvenile sturgeon are rearing (Flory 2011). In the future, as sturgeon are encouraged to migrate and spawn in locations upstream of the Meander Reach, nutrient additions to the Canyon Reach may serve as a food source to juveniles under future spawning scenarios.

Under the Proposed Action, the results of the nutrient enhancement programs will be monitored as part of M&E. Although the programs have not provided additional documented food sources for juveniles in the Meander Reach, the data thus far indicate that fish populations in the river upstream of Bonners Ferry have responded positively to increased phytoplankton and macroinvertebrate production (Hoyle et al. 2014; Minshall et al. 2014). Similarly, Kootenay Lake fertilization will occur outside of the Action Area, but this activity has increased zooplankton production, and has led to an increased kokanee salmon population, benefitting sturgeon that are located within the Action Area. The continuation of this program will benefit sturgeon.

Habitat Restoration

The habitat restoration projects will support sturgeon life-history requirements. Proposed projects include floodplain enhancement, wetland restoration, tributary restoration, substrate enhancement, and the continuing development of riparian vegetation.

It is expected that implementation of habitat restoration projects, such as floodplain reconnection and riparian restoration, will increase primary productivity by improving conditions for lower trophic level organisms, including juvenile sturgeon. These projects are also expected to improve natural recruitment through increasing hydraulic complexity and supporting sturgeon spawning and early life stages by increasing channel depths, high-velocity habitat, and availability of rocky substrate. Floodplain enhancement will provide off-channel refugia for juvenile fish. Restoring tributaries will support sturgeon life stages, while developing a riparian vegetation buffer will provide habitat and water quality

protection. Restoration activities would also make the habitat more tolerant of natural disturbances (KTOI 2009) and future effects from climate change.

Short-term, direct effects to sturgeon from construction activities could include mortality or injury from equipment or materials used for restoration, or physiological stress from noise; however, all projects will go through appropriate environmental compliance and permitting processes prior to implementation, and will incorporate best management practices to avoid and minimize construction-related impacts. Habitat restoration actions would address sturgeon PCEs and improve habitat conditions in the Action Area, which could increase natural recruitment.

Research, Monitoring, and Evaluation

The RM&E program will result in the continued integration of the most current and applied biology. The RM&E program relies on knowledgeable local and regional subject area experts to address critical uncertainties, including specific recruitment failure mechanisms and the interaction of limiting factors to improve understanding of the sturgeon's biological requirements and habitat needs. Continuation of the RM&E program will increase the sturgeon knowledge base and aid in refining management measures, which may improve natural spawning and recruitment, eventually leading to an increase in the wild population to a level where supplementation from the conservation aquaculture program would no longer be required. RM&E actions will therefore indirectly benefit sturgeon in the long term. Some projects underway for RM&E include sampling and handling of fish, which could result in direct take (injury or mortality) of some individuals; however, the potential long-term benefits to the species are substantial.

3.3.2.7 Effects on Sturgeon Critical Habitat

Operations of Libby Dam under the Proposed Action will be consistent with recommendations by the FPIP Technical Team, to the extent practicable, for providing water for critical habitat features, including water depth, velocity, and temperature to benefit sturgeon. Libby Dam's operations must be consistent with all of the project's authorized purposes, however, which include FRM as well as fish and wildlife, among others. Thus, augmentation flow actions may be occasionally be limited and unlikely to reach velocities or depths that would provide optimal spawning and rearing conditions, due to flow constraints imposed by other project purposes. Kootenai River habitat projects are also expected to improve critical habitat conditions by increasing primary productivity and increasing or improving spawning and rearing habitat. Construction activities associated with habitat improvement projects have the potential to temporarily affect critical habitat; these projects will go through the appropriate environmental compliance and permitting processes prior to implementation. The conservation aquaculture program will have no effect on critical habitat.

Although the Proposed Action is expected to have adverse effects to some sturgeon critical habitat PCEs, the conservation measures that are integrated into the Proposed Action are expected to reduce these adverse effects. The effects of the Proposed Action on each PCE are described as follows:

PCE 1: A flow regime, during the spawning season of May through June, that approximates natural variable conditions and is capable of producing depths of 23 feet (7 m) or greater when natural conditions (for example, weather patterns, water year)

allow. The depths must occur at multiple sites throughout, but not uniformly within, the Kootenai River designated critical habitat.

The degree to which the current flow regime has achieved this PCE is discussed above. Under the Proposed Action, Libby Dam would continue to be operated following VARQ FRM procedures and tiered sturgeon releases within the ongoing adaptive management framework, which allows for adjustments that may serve the goal of achieving depths of 23 feet (7 m) or greater in all spawning reaches, including the Braided Reach, where the most ideal spawning substrate within the listed critical habitat occurs. While Libby Dam will continue to be operated in an effort to achieve the goal of 23-foot (7-m) depth criteria over rocky substrate in the Braided Reach, under current conditions this would require exceedance of a 1,764-foot river stage at Bonners Ferry. There may be extreme cases where Libby Dam is regulated to keep the Bonners Ferry stage at 1,770 feet (539 m) or another target chosen to balance downstream flood stages and control refill of Lake Kootenai (Corps 1999), but in general, this depth criterion may not be achievable in all locations. However, habitat projects completed upstream of the Meander Reach have increased the likelihood of achieving the depth criterion when natural conditions (e.g., weather patterns, water year) allow.

PCE 2: A flow regime, during the spawning season of May through June, that approximates natural variable conditions and is capable of producing mean water column velocities of 3.3 ft/s (1.0 m/s) or greater when natural conditions (for example, weather patterns, water year) allow. The velocities must occur at multiple sites throughout, but not uniformly within, the Kootenai River designated critical habitat.

According to simulation results of Barton et al. (2010), minimum velocities of 3.3 ft/s were met along the length of the Braided Reach nearly consistently during the 2006–2009 spawning seasons and were met in some or all of the length of the Straight Reach, but not in the Meander Reach. This can be expected to continue with the flow constraints under which Libby Dam will continue to operate under the Proposed Action.

PCE 3: During the spawning season of May through June, water temperatures between 47.3°F and 53.6°F (8.5°C and 12°C), with no more than a 3.6°F (2.1°C) fluctuation in temperature within a 24-hour period, as measured at Bonners Ferry.

This PCE was achieved for almost all days throughout May and June of 2006–2015 (calculated), as well as through 2018 as discussed previously. Under the Proposed Action, it is expected that this temperature range can be maintained by allowing stratification to develop and strengthen in the Libby Dam forebay before warm water is released via selective withdrawal operations. The conclusion that this PCE will be maintained or improved under the Proposed Action assumes no exceptional weather patterns causing strong atmospheric cooling, and relative lack of continuous strong south wind that blows warm water away from the forebay, in turn causing a sudden upwelling of cold water at the selective withdrawal system.

PCE 4: Submerged rocky substrates in approximately 5 continuous river miles (8 river kilometers) to provide for natural free embryo redistribution behavior and downstream movement.

The substrates present in the Braided, Straight, and Meander reaches are discussed above. These substrates would not be altered by flow regimes under the Proposed Action. Potential habitat

improvement projects could include substrate enhancement in the reaches, which would have a positive effect on this PCE in the future.

PCE 5: A flow regime that limits sediment deposition and maintains appropriate rocky substrate and inter-gravel spaces for sturgeon egg adhesion, incubation, escape cover, and free embryo development.

Libby Dam flow releases for sturgeon have provided, and will continue to provide, velocities sufficient to maintain exposed gravel and cobble in the Braided Reach and exposure of gravel and bedrock in the Straight Reach. Due to backwater effects from Kootenay Lake, as well as flow constraints imposed by other project purposes, Libby Dam flow releases are unlikely to affect velocities in the Meander Reach to the extent needed to reliably expose clean substrate.

3.3.2.8 Summary of the Effects of the Proposed Action on the Species and Critical Habitat

Current sturgeon population models estimate that the existing wild population may be larger than previously thought; however, natural production is virtually non-existent (i.e., recruitment failure) (Beamesderfer et al. 2014). Additionally, higher-than-pre-dam winter water temperatures may create increased metabolic demand in juveniles, exacerbating their risk of starvation during a normally food-limited time of year.

Effects of the operational portions of the Proposed Action on migration, spawning, incubation, and rearing have been discussed above. Libby Dam operations do not appear to affect survival of mature adults. Egg-to-larval and larval-to-age-two survival appear to be the primary limiting factors for the survival and recovery of this species; hence, the focus on potential causal relationships between dam operations and recruitment failures.

Despite operational changes that have been made since the construction of Libby Dam to benefit this species, sturgeon recruitment based on natural spawning has not been documented at appreciable levels under a variety of flow and temperature combinations in release timing to date. Depth criteria in the Braided Reach cannot be fully met without exceeding flood stage at Bonners Ferry. Adaptive management of operations will continue, but it is unknown what further capacity for sturgeon reproductive response exists within the capabilities and imposed parameters and constraints of seasonal dam operation and floodplain separation (levees) and development at and downstream of Bonners Ferry.

While measures identified under the Proposed Action are designed to improve fish and wildlife habitat, operators also must address Libby Dam's multiple authorized purposes. Under the Proposed Action, management actions are limited by the amount of discretion the Corps has to prioritize sturgeon flow and habitat needs above other purposes of Libby Dam, primarily FRM. The proposed modified draft and sliding scale at Libby Dam provide greater flexibility to provide temperature and flow conditions to support resident fish, but are unlikely to result in quantifiable benefits specific to Kootenai River white sturgeon. Thus, although flows have been and will continue to be managed to achieve PCEs for sturgeon, augmentation flows may be limited by FRM priorities, and may not always achieve reach velocities and depths that would be most beneficial to sturgeon and their habitat. While the dam operations in the Proposed Action are expected to reduce adverse effects to sturgeon and their habitat in the Action Area, the limitations placed on the flow management regime may preclude avoidance of

adverse effects on sturgeon and their habitats. The Action Agencies will continue to make operational adjustments based on best available scientific information to improve habitat conditions for sturgeon in the Action Area.

Bonneville will continue to support recommended mitigation measures in the Kootenai River, including aquaculture, nutrient additions, habitat actions, and research and M&E, as appropriate. In particular, implementation of Tier 1 habitat actions that include riparian forest restoration, such as the black cottonwood plantings proposed as part of the EIS, should improve overall ecosystem condition and benefit Kootenai River white sturgeon. In combination with adaptively managing flows to achieve sturgeon critical habitat PCEs, the Proposed Action will further support sturgeon recruitment, including improving sturgeon habitat, and continue to increase the knowledge base of sturgeon needs in the Kootenai River system to allow continued refinement of operations. Based on the effects described above, the Proposed Action may affect, and is likely to adversely affect, both Kootenai River white sturgeon and their designated critical habitat.

3.3.2.9 Summary of Effects to the Species

Continued operations of Libby Dam may adversely affect Kootenai River white sturgeon during maintenance activities that require one or more generating units to go offline. It is anticipated that all 5 of Libby Dam's turbines will be taken off line - one unit per Water Year (likely, but not necessarily consecutively) - for a 6-9 month period during the extent of this consultation for the purposes of unit rewinding; these outages will be scheduled to avoid periods of required all-unit availability (i.e. FRM and Kootenai River white sturgeon spawning). Should outages extend beyond anticipated and planned duration, the FPIP team will coordinate with engineers to adaptively manage discharge timing and shape for sturgeon flow augmentation operations; the FPIP team has adaptively managed tiered volumes since 2006 (variable volume availability, variable temperature availability, variable channel capacity), and experimental flows have successfully included operations that encompass use of only 4 turbines. However, outages that extend beyond 9 months are unlikely, and not anticipated.

In years when flow augmentation does not appreciably increase river depth, adult sturgeon's access to preferred spawning habitat may be limited. In late fall and winter, warmer than normal winter water temperatures may increase the metabolic rates of juvenile sturgeon, and thus feeding activity, which may increase the risk of starvation. In addition, nutrient deficits downstream of the dam have created a nutrient poor environment, which may impact sturgeon prey base and forage.

Many other on-going mitigation activities, including conservation aquaculture, nutrient supplementation, and habitat restoration, along with activities not included as part of the Proposed Action, will continue to provide benefits for Kootenai River white sturgeon.

SUMMARY OF EFFECTS TO CRITICAL HABITAT

Continued operations of Libby Dam may adversely affect Kootenai River white sturgeon critical habitat when PCE criteria are not met, which occurs seasonally and infrequently. While Libby Dam will continue to be operated in an effort to achieve the appropriate flow regimes for sturgeon, some criteria may not be achievable in all locations at all times. Specifically, flow regimes that enable achievement of depth criteria (PCE1) are dependent upon reservoir inflow volume (tiered volumes) and Kootenay Lake

backwater extent, and may not achieve desired depths despite dam operations. Similarly, inflow volume forecasts govern Lake Kootenai elevation through the winter, which in turn influences thermal mass of the reservoir; storage of cold thermal mass can have deleterious effects on the ability to provide appropriate discharge temperatures during May and June (PCE 3).

Table 3-79 summarizes effects by PCE.

Table 3-79. Summary comparison of the effects of the Proposed Action to current conditions for Kootenai River white sturgeon

PCE	PCE Description (Abbreviated)	Effects of the Proposed Action
1	A flow regime that approximates natural variable depth conditions, during the spawning	Seasonal adverse effect when sturgeon flows can't be met
2	A flow regime that approximates natural variable velocities during the spawning	Seasonal adverse effect in both the straight reach (occasional) and the Meander Reach
3	Appropriate water temperatures for spawning	Occasional, temporary adverse effect
4	Submerged rocky substrates	Adverse effect due to discharge constraints for FRM
5	A flow regime that limits sediment deposition and maintains appropriate rocky substrate	Adverse effect in Straight Reach and Meander Reach

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 (40 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.

The Action Agencies assume that many impacts from non-federal activities in the Action Area that have degraded or hindered the conservation of listed species will continue in the short term and in the foreseeable future at similar intensities as in the recent past. The types of ongoing non-federal activities and land uses expected to continue to affect listed species and critical habitat within the Action Area include development, agricultural conversion, fish hatcheries, timber harvest and road construction, coal mining, renewable energy development, water demand and storage, fisheries management and harvest, habitat improvement, and invasive species. Climate change is often considered a reasonably foreseeable future effect. The impacts of climate change are discussed in detail in Section 3.1.1.6. The potential cumulative effects of current land uses, water, and other resource uses are described below.

3.4.1 Residential, Commercial, and Infrastructure Development

Human populations are increasing primarily in urban metropolitan areas with smaller increases in rural areas. This increase is expected to continue until at least 2030 (U.S. v. Oregon 2018). Population increases in the Columbia River Basin are projected to continue although there is a wide range of estimates of the specific number. Projections to 2040 of population growth rates for the interior Columbia River Basin range from 0.3 percent per year to 1.6 percent per year. Lackey et al. (2006) concluded that if the largely migration-driven population growth continues unabated, it will result in a threefold to sevenfold increase in the population in the Columbia River Basin region. In Washington and Oregon, many acres of forest lands are being converted to residential and commercial development, a trend that is expected to continue.

Agricultural land is also being converted to nonagricultural uses. Like forestland, a major factor influencing the conversion of agricultural land is the increase in land prices driven by population growth. Urban development causes marked changes in the physical, chemical, and ecological characteristics of stream ecosystems, which are in most cases detrimental to native fish and wildlife. The rate of exurban development also appears to be increasing. This type of development tends to result in degraded habitat for fish and wildlife through direct habitat conversion and loss. Human population growth and development can be expressed as potential causes of increases in discharges of pollutants in stormwater runoff from residential, commercial, industrial, agricultural, recreational, and transportation land uses.

A variety of population-driven factors external to the Columbia River Basin can also cause effects within the basin. International trade through shipping has led to modifications to the lower river and estuary. Future channel deepening may result in increasing numbers of ships and cargo tonnage on the river. Globalization of trade may have contributed to the loss of some industries within the Columbia River Basin, such as aluminum, and will continue to affect resource-based industries. Increased volumes of materials, especially hazardous goods and fuels that power trains, vessels, and trucks, are moved through the Columbia River Basin in response to the demands of a growing population. With increased

movement of goods via all three modes, more accidents and spills are likely. Mining, trade, and transportation projects also influence the hydrology, water quality, and use of the Columbia River system.

Primary pathways of potential effects of land and infrastructure development on ESA-listed NMFS and FWS species, and their respective designated critical habitat, includes the following: riparian vegetation removal and habitat loss, decreased water quality, sediment loading, contaminants in waterways, changes in runoff patterns, floodplain conversion, habitat fragmentation, isolation of populations (e.g., through use of human-made barriers such as perched culverts or water diversions), and loss of habitat diversity. Based on past trends and types of development, future residential, commercial, recreational, and infrastructure development is likely to increase in the Action Area. State and local regulations, as well as state and private conservation plans, are expected to mitigate some of the potential effects of development and may reduce the impacts to listed species and riparian habitat.

3.4.2 Water Withdrawals for Municipal, Agricultural, and Industrial Uses

Freshwater withdrawals for domestic, industrial, commercial, and public uses are increasing, whereas withdrawals for irrigation purposes are decreasing due to the conversion of agricultural lands to residential areas. Freshwater withdrawals for domestic and public uses are projected to increase by 71 to 85 percent by 2050. Freshwater withdrawals for irrigation are projected to decline but will be more than offset by increases in withdrawals for public, domestic, industrial, and commercial uses. Increased withdrawals have large implications for instream flow and for maintenance of riparian and aquatic habitats for fish and wildlife.

Many tributaries in the Columbia River Basin are significantly depleted by water diversions by non-federal entities. In 1993, state, tribal, and conservation group experts estimated that 80 percent of 153 Columbia tributaries had low flow problems, of which two-thirds were caused, at least in part, by irrigation withdrawals (Kline and Fuji 1993). The Northwest Power and Conservation Council showed similar problems in many Idaho, Oregon, and Washington tributaries (NPCC 1992). Diminished tributary stream flows have been identified a major limiting factor for most species in the Columbia River Basin upstream of Bonneville Dam (NMFS 2007). Tributary water diversions added are expected to continue in the future over the study period.

There would be an overall adverse effect from reduced availability of water from increased demand. In addition, tributaries that are significantly depleted by water diversions will continue to be a major limiting factor for most species in the Columbia River Basin upstream of Bonneville Dam.

3.4.3 Increase in Demand for New Water Storage Projects

A general trend of increased water storage needs in the Columbia River Basin is projected to continue to encourage new water storage projects. Some of the larger future projects that overlap with the CRSO EIS include the following:

- **Switzler Reservoir Water Storage Project:** The reservoir would have a peak storage capacity of approximately 44,000 acre-feet through construction of a concrete-faced rockfill dam approximately 325 feet in height and located approximately 1.1 miles upstream of the confluence of the Switzler drainage with the Columbia River.

- **Swan Lake North Closed Loop Pumped Storage Facility:** The proposed project, which would be located about 11 miles northeast of Klamath Falls in Klamath County, Oregon, would be located within the northern portion of the 1,650-square-mile Lost River Basin. The proposed project would use off-peak energy (i.e., energy available during periods of low electrical demand) to pump water from the lower reservoir to the upper reservoir and generate energy by passing the water from the upper to the lower reservoir through generating units during periods of high electrical demand.
- **Goldendale Closed Loop Pumped Storage Facility:** The proposed Goldendale Energy Project No. 14861 is a closed-loop pumped storage hydropower facility proposed by FFP Project 101, LLC. The proposed lower reservoir would be off-stream of the Columbia River at John Day Dam, located on the Washington (north) side of the Columbia River at River Mile 215.6. The project would be located approximately 8 miles southeast of Goldendale in Klickitat County, Washington.

There is potential for adverse effects from changes to timing, delivery, and quantity of water in different locations from new storage projects. Certain of these projects, or components of them, could be subject to federal permitting or licensing processes and therefore subject to section 7 consultation.

3.4.4 Agricultural and Floodplain Conversion

Although federal, tribal, state, and local actions seek to improve riparian habitat and reconnect floodplains with rivers for habitat restoration purposes throughout the proposed Action Area, it is expected that the majority of existing impacts from isolation of floodplains and conversion to farmland will continue. Additional riparian impacts from infrastructure development, road construction, levee building, and bank armoring on private lands will likely occur in the future. As in the past, these activities will remove riparian vegetation, disconnect rivers from their floodplains, interrupt groundwater-surface water interactions, reduce stream shade (and thereby increase stream temperature), reduce off-channel rearing habitat, and reduce the opportunity for large woody debris recruitment. Watershed assessments and other education programs may reduce these adverse effects by continuing to raise public awareness about the potentially detrimental effects of agricultural-related development on fish habitats and by presenting ways in which a growing human population and healthy fish populations can co-exist.

3.4.5 Fish Hatcheries

There are numerous hatcheries in the Columbia River Basin that focus on conservation of rare species and/or maintaining the abundance of recreational species. Hatchery programs in the Columbia River Basin are implemented to augment harvest, to help conserve a population, or for both purposes. There are more than a hundred non-Federal hatchery programs funded through various sources and operated by tribes and state agencies. Many of the hatchery programs are intended to mitigate for lost habitat, mortality of juvenile and adult fish, and other impacts of hydroelectric dams. It is anticipated that the action agencies and other partners will continue to fund the operation and maintenance of hatchery programs.

Hatcheries would continue to benefit overall anadromous populations that are increased through stocking. There are also adverse impacts that would continue to occur from interactions between stocked and naturally reproduced fish.

3.4.6 Timber Harvest and Road Construction

Private timber harvest and similar activities, including road maintenance, new road construction, and logging, are expected to continue within the proximity of portions of the Action Area, which may decrease bank stability, increase sediment loading, and affect riparian vegetation and spawning reaches. These actions, while generally occurring in upland areas well outside the Action Area, may increase sediment discharge upstream of reservoirs of dams that can contribute to turbidity and reduced water quality in the reservoirs/lakes. Below the dams, high flows can wash significant amounts of sediment due to timber harvest from tributaries into rivers, such as the Fisher River into the mainstem Kootenai River. This can create turbidity in the rivers that may have some benefits, such as providing cover from predators for sturgeon eggs and larvae. However, the negative effects of excessive sediment loading can include suffocation of bull trout and sturgeon eggs. Sediment from logging or multiple-use dirt roads and timber harvest can also wash downstream in tributaries and deposit sediments at their confluences with mainstem rivers or reservoirs, which may result in connectivity issues if sediment build up hinders tributary-mainstem migrations. The impacts could be exasperated by reservoir elevation changes from the Proposed Action, as well as future patterns of run-off flow as a result of climate change.

3.4.7 Coal Mining

Coal mining activities in the Elk River drainage in British Columbia have led to increased levels of selenium contamination in Lake Kooconusa and the Kootenai River (Kennedy et al. 2000). Elevated selenium concentrations have been detected in some bull trout in Lake Kooconusa. USFWS (2015b) recommends continued monitoring of the selenium levels in the Kootenai River system and research on the impact of selenium on bull trout, particularly with respect to potential reproductive impairment (including adult reproductive failure and early life stage teratogenicity and mortality) (Lemly 2002), because this threat is not yet well understood. Use of ammonium nitrate in blasting for coal mining in British Columbia upstream of Lake Kooconusa is also thought to have raised total nitrogen and NO₃ levels in Lake Kooconusa (G. Hoyle, Kootenai Tribe of Idaho, pers. comm., 2015; K. Easthouse, Corps Seattle District, pers. comm., 2015). The use of ammonium nitrate blasting is expected to continue, and probably 25 percent of these constituents will be trapped in Lake Kooconusa, while the remainder travels downstream. The effects from coal mining may affect bull trout and Kootenai River white sturgeon within the Action Area upstream and downstream of Libby Dam.

3.4.8 Bycatch and Incidental Take

This refers to incidental take and/or bycatch of fish species such as ESA-listed salmon or bull trout by recreational anglers and incidental take of eulachon by shrimp fishing. Bycatch and incidental take are forecast to continue alongside recreational and commercial harvest. Bycatch of listed species and incidental take would continue to have an adverse effect.

3.4.9 Ongoing and Future Habitat Improvement Actions for Bull Trout

A common goal among habitat improvement projects is the improvement of aquatic habitat and water quality to benefit native salmonids, especially bull trout. A comprehensive list of activities that

contribute to the recovery of bull trout in the Columbia River Recovery Unit and Lake Pend Oreille area is not available because of the variety of state, tribal, and non-governmental organizations that conduct activities in the region. Some of the major activities that are ongoing or have been recently completed within the region are as follows:

- Construction of upstream fish passage facility at Box Canyon Dam (construction began in 2016, facility expected to be operational in 2019; Pend Oreille Public Utility District)
- Lake trout removal in Lake Pend Oreille (Idaho Department of Fish and Game)
- Tributary habitat restoration, enhancement, and passage
- Kalispel resident fish project (Kalispel Natural Resources Department)
- Road abandonment and bank stabilization (Kalispel Natural Resources Department)
- Bull trout research and monitoring
- Genetic inventory of bull trout in the Pend Oreille River subbasin (Kalispel Natural Resources Department)
- Kalispel resident fish project (Kalispel Natural Resources Department)
- Mainstem Pend Oreille River water quality
- Temperature total maximum daily load (TMDL) implementation for the Pend Oreille River (Washington Department of Ecology and stakeholders)
- Water quality monitoring (Kalispel Natural Resources Department)

A common goal among these plans is the improvement of aquatic habitat and water quality to benefit native salmonids, especially bull trout as the target species.

3.4.10 Tribal, State, and Local Fish and Wildlife Improvement

These actions include non-Federal habitat actions 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. Actions and programs contributing to these benefits include growth management programs, 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, hydraulic project permitting, and increased spill and bypass operations at non-Federal hydropower facilities.

New tribal, state, and local fish and wildlife improvement projects are projected to restore, maintain, create, or enhance fish and wildlife habitat. Many of these projects are focused on benefiting anadromous species, bull trout, and Kootenai River white sturgeon.

3.4.11 Invasive Species

Non-native and invasive plants and animals are currently damaging biological diversity and ecosystem integrity across the Columbia River Basin and within the study area. Aquatic species are of particular concern because they spread rapidly and can quickly alter the function of an ecosystem. Throughout the

study area, the state and local tribes are involved with cooperative weed management efforts, invasive species prevention and eradication, and vegetation treatments.

There is a projected increase in northern pike and other species that prey on salmonids. Non-native fishes such as walleye, smallmouth bass, and channel catfish are also present in slower-moving areas throughout the Columbia River Basin.

3.4.12 Summary of Cumulative Effects

Future trends or changes in these land- and water-use patterns, including but not limited to ownership, development, and intensity, could affect all species considered in this consultation, and their respective designated critical habitat. Modifications to state, tribal, and local government land and water uses are likely to be implemented in the form of legislation, administrative rules, or policy initiatives. The cumulative effects of ongoing non-federal activities in conjunction with the Action Agencies' Proposed Action are difficult to quantify, considering the broad geographic landscape covered by this consultation, the geographic and political variation in the Action Area, the uncertainties associated with government, tribal, and private actions, and ongoing changes in the region's economy. Whether these potential effects will increase or decrease in the future is a matter of speculation; however, based on current land management practices, population and growth trends, and climate change models, adverse cumulative effects are likely to increase.

3.5 NOT LIKELY TO ADVERSELY AFFECT SPECIES

The Action Agencies reviewed the listed species that may occur in the action areas. During the information-gathering and initial analysis stages, the Action Agencies concluded that some of the ESA-listed species were not likely to be affected by the proposed actions and further analysis for these species was unnecessary. Section A.3 presents, for information only, the rationale behind these determinations.

3.5.1 NOAA Not Likely to Adversely Affect Species

3.5.1.1 *Green Sturgeon – Southern DPS*

North American Green Sturgeon are broadly distributed in nearshore marine areas from Mexico to the Bering Sea. There are two DPSs that co-occur through much of their range, but use different river systems for spawning. The Northern DPS consists of populations spawning in systems in and north of the Eel River in Humboldt County, California. (Known spawning populations are in the Eel, Klamath, and Rogue Rivers). The Northern DPS is not listed under the ESA, but is a NMFS Species of Concern. The Southern DPS consists of populations spawning in rivers south of the Eel River (with all known spawning occurring in the Sacramento River and its tributaries). The Southern DPS was listed as threatened in 2006 [(71 FR 17757 2006), April 7, 2006]. Critical Habitat was designated in 2009 [74 FR 52300 (2009) , October 9, 2009]; in the Columbia River designated critical habitat extends up to river kilometer 74 (approximately river mile 46, near the upstream end of Puget Island). A Recovery Plan was released in 2018 (NMFS 2018b).

Adult and subadult green sturgeon migrate seasonally along the West Coast, congregating in bays in estuaries in Washington, Oregon and California in summer and fall. One study detected green sturgeon (DPS unknown) in the Columbia River up to river mile 23.5, although most fish stayed much closer to the mouth of the river, with an average residence time of a few days (Hansel et al. 2017). The best available evidence indicates the Southern DPS uses the Columbia only for feeding; the only evidence of spawning in the Columbia River is the collection of a single age-0 individual from the non-listed Northern DPS (Schreier et al. 2016).

In its 2019 BiOp (NMFS 2019) NMFS found the Proposed Action was not likely to adversely affect Southern DPS green sturgeon and its designated critical habitat, because all the effects of the Proposed Action were either discountable or insignificant. The Action Agencies believe the effects of the current Proposed Action will be similar those considered in that 2019 BiOp. The Action Agencies have not found any new information published since the date of that 2019 BiOp. In addition, as part of the Proposed Action, the Action Agencies intend to continue their improvement of estuary habitat, which may contribute to the prey base for feeding adult Southern DPS green sturgeon. Based on the above, the Action Agencies have determined the Proposed Action is not likely to adversely affect Southern DPS green sturgeon and its designated critical habitat.

3.5.1.2 South Resident Killer Whale

The Southern Resident killer whales (SRKW) distinct population segment (DPS) was listed as endangered on February 16, 2006 [final rule effective – listed in (70 FR 69903 2005) November 18, 2005]. The SRKW DPS is comprised of three pods, designated J, K, and L. During the spring, summer, and fall months, the SRKW can be found in the inland waters of Puget Sound, the Northwest Straights, and southern Georgia Strait. In the winter, they range as far south as Monterey Bay, California and as far north as the Queen Charlotte Islands. The current population is estimated at 73 (<https://www.whaleresearch.com/orca-population>, last accessed September 6, 2019).

The final recovery plan for the SRKW identified numerous external factors that may be limiting recovery of this species (NMFS 2008c). These included toxic contaminants that accumulate in top predators, disturbance from marine vessel traffic/noise, and quantity and quality of prey (NMFS 2008c). While management of the Columbia River System does not directly affect SRKW, operations do directly affect Chinook salmon (both natural origin and hatchery) that migrate past these federal dam and reservoir projects. This may indirectly affect SRKW by influencing some proportion of prey availability originating from the Columbia and Snake river basins.

On November 29, 2006, NOAA Fisheries designated critical habitat for SRKW (71 FR 69070 2006). The designated area was limited to the Strait of Juan de Fuca and parts of Puget Sound. Primary Constituent Elements (now referred to as Physical or Biological Features or PBFs) identified in that designation were:

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

Passage conditions to allow for migration, resting, and foraging.

On September 19, 2019, NOAA Fisheries proposed an expansion of critical habitat to include waters along the Pacific Coast between Cape Flattery, Washington, and Point Sur, California (84 FR 49214). While several sub-areas were proposed, the overall area extends from Cape Flattery and the Strait of Juan de Fuca down to Point Sur, south of Monterey Bay, and from the 6.1 meter (20-foot) isobath contour out to the 200 meter isobaths contour. (One area off the central Washington coast was excluded for national security reasons.) No change was proposed to the PBFs listed above.

The action area for Southern Resident killer whales includes all areas off the Pacific Coast where salmonid species from the Columbia River, which are affected by the projects or programs of the CRS, are available as prey for listed Southern Resident killer whales. This area encompasses the whales' entire coastal range from the Columbia River's mouth and plume south to southern Oregon and north to the Queen Charlotte Islands.

NOAA Fisheries has analyzed Chinook salmon stocks based on their estimated importance to the whales and found that the most crucial stocks are those returning to the Fraser River in British Columbia, other rivers draining into Puget Sound and the Salish Sea, and the Columbia, Snake, Klamath, and Sacramento rivers. NOAA Fisheries' analysis showed that Puget Sound Chinook salmon stocks are one of the most important salmon stocks for Southern Resident killer whales, since they surround the heart of the whales' habitat, and the whales have access to them for a greater part of the year than fish from the Columbia, Snake, and Fraser rivers. In the Columbia River Basin, different stocks vary in overall

importance for the diet of SRKW. For example, SR spring-summer Chinook salmon are mainly available to SRKW when the fish gather off the mouth of the Columbia, whereas SR fall-run Chinook remain closer to the coast and would be available for a longer period before migrating upriver in the fall (NMFS 2014a; NMFS and WDFW 2018).

In 2008, NOAA Fisheries concurred with the Action Agencies' determination that system management may affect, but were not likely to adversely affect SRKW (NMFS 2008d; Reclamation et al. 2008). This determination was based on expected status improvements for prey originating from the Columbia as a result of three key factors: (1) previous modifications to system operations and configuration to benefit salmonids; (2) ongoing artificial production programs in the Columbia River Basin; and (3) implementation of the 2008 BiOp's RPA actions, with further improvements to mainstem migration conditions, spawning and rearing habitat, predator management, and hatchery reforms (Reclamation et al. 2008).

In light of the complexities inherent in parsing sources of mortality associated with system management from other anthropogenic as well as natural sources, NOAA conservatively calculated total mortality for fall Chinook, a key prey species, through the mainstem and compared this estimate to increased numbers of Chinook salmon produced from hatchery programs supported by the Action Agencies. NOAA concluded this production "more than mitigates for" total mortality in the mainstem migratory corridor from all sources (NMFS 2008d; p. 9-17). In light of further expected improvements to the status of listed Chinook stocks in the long term as a result of the 2008 RPA, and the near-term offsets to all sources of mainstem mortality provided by artificial production, NOAA Fisheries concurred with the Action Agencies' determination that system operations may affect, but were not likely to adversely affect SRKW (NMFS 2008d).

In 2014 and again in 2019, NOAA confirmed the continuing validity of the analyses and conclusions from the 2008 consultation, once again based in part (and conservatively) on the fact that Chinook salmon hatchery production supported by the Action Agencies more than offsets near-term losses to the SRKW prey base resulting from all sources of mortality through the mainstem migratory corridor (NMFS 2014a; see p. 487; 2019; see p. 908).

For the Columbia and Snake River Chinook salmon prey source, past improvements to the configuration and operation of the Columbia River System described in this chapter, additional improvements to the environmental baseline as a result of completed estuary and tributary habitat actions, and the prospective non-operational conservation measures proposed in Chapter 2, all contribute towards maintaining and improving Chinook abundance. Relevant conservation measures include, among other things, a commitment to continue funding the conservation and safety net hatchery programs listed in Chapter 2. With respect to the environmental baseline, the Action Agencies have continued independent responsibilities to fund existing hatchery programs that help fulfill mitigation objectives established by Congress in the authorizations to construct and operate individual dam and reservoir projects within the Columbia River System, including Grand Coulee Mitigation, John Day Mitigation, and programs funded and administered by other entities, such as the lower Snake River Compensation Plan. The Action Agencies will fulfill congressionally authorized hatchery mitigation objectives through the funding of hatchery programs that are operated consistent with their independent hatchery program consultations during the term covered by this consultation. Based on those hatchery program consultations, the production levels associated with congressionally authorized hatchery mitigation

objectives will continue, at minimum, to be consistent with levels previously analyzed by NOAA in the system consultations in 2008, 2014, and 2019.

For this consultation, therefore, the Action Agencies expect that collectively, all of the actions described above (substantial modifications to migration conditions designed to benefit key prey species, combined with improvements to Chinook spawning and rearing habitat in the tributaries and Columbia River estuary, and continued hatchery production) ensure that remaining Chinook mortality from all sources in the mainstem migratory corridor will continue to be more than offset, resulting in a net gain in Chinook abundance available as a prey source for SRKW.

Any remaining Chinook mortality attributable to the Proposed Action is only a subset of the total mortality from all sources within the mainstem migratory corridor. Therefore, the Action Agencies have determined that management of the CRS may affect, but is not likely to adversely affect, the SRKW species or designated critical habitat.

3.5.2 FWS Not Likely to Adversely Affect Species

In their 2000 BiOp, the USFWS concurred with the Action Agency's determination of NLAA for species identified in Table 3-80. In general, effects of the Proposed Action are considered to be insignificant or discountable. Since the issuance of that 2000 BiOp, all of these species remain listed under the ESA, including Spalding's silene, which changed from "proposed" to "threatened." In addition to those species, several additional species in the region are now listed as threatened that may occur within the vicinity of the Action Area (Table 3-81). The Action Agencies reviewed each of these species to determine whether the management of the CRS "may affect" any of these species and/or their designated critical habitat. In general, these species are terrestrial and are unlikely to be exposed to operational actions associated with management of the CRS. Nonetheless, the Action Agencies considered each and prepared the following evaluation in support of the determination that these species and/or their designated critical habitat is not likely to be adversely affected by the continued operation and maintenance of the CRS.

Because operational and structural changes to the Proposed Action since 2000 have focused primarily on activities at the mainstem dams to improve downstream passage survival of juvenile anadromous salmonids and conditions for resident aquatic species, it is extremely unlikely that these changes resulted in new or previously unforeseen effects to those species identified in Table 3-80 and to which the USFWS' concurred with a NLAA determination in their 2000 BiOp.

Table 3-80. List of species USFWS concurred with Action Agencies' determination of NLAA in 2000 BiOp. The changes in the Proposed Action do not result in changes to the potential effects to these listed species.

Species	Status
Grizzly bear (<i>Ursus arctos horribilis</i>)	Endangered
Gray wolf (<i>Canis lupus</i>)	Endangered
Woodland caribou (<i>Rangifer tarandus caribou</i>)	Endangered
Canada Lynx (<i>Lynx canadensis</i>)	Threatened
Northern Idaho ground squirrel (<i>Uroditellus brunneus</i>)	Threatened
Macfarlane's four o'clock (<i>Mirabilis macfarlanei</i>)	Threatened
Water howellia (<i>Howellia aquatilis</i>)	Threatened
Ute's ladies' tresses (<i>Spiranthes diluvialis</i>)	Threatened
Spalding's silene (<i>Silene spaldinii</i>)	Proposed

Table 3-81. Species the Action Agencies are requesting concurrence with a determination of NLAA for the CRS consultation. The FWS provided this list to the Action Agencies and requested an additional concise evaluation of potential effects.

Species	Status
Grizzly bear (<i>Ursus arctos horribilis</i>)	Endangered
Columbian white-tailed deer (<i>Odocoileus virginianus leucurus</i>)	Threatened
Streaked horned lark (<i>Eremophila alpestris strigata</i>)	Threatened
Yellow-billed cuckoo (<i>Coccyzus americanus</i>)	Threatened
Ute's ladies' tresses (<i>Spiranthes diluvialis</i>)	Threatened

For those other species the USFWS previously concurred with the Action Agencies determination of NLAA in their 2000 BiOp (Table 3-52), the Action Agencies intend to rely on that previous determination that operation and maintenance of the CRS is not likely to adversely affect those species. Of the non-aquatic ESA-listed species that may occur within the vicinity of the Action Area, the Action Agencies concluded that the species identified in Table 3-81 warranted further discussion. The Action Agencies reviewed these remaining species and prepared the following evaluation in support of the determination that these species and/or their designated critical habitat are not likely to be adversely affected by the Proposed Action.

3.5.2.1 Grizzly Bear (*Ursus arctos horribilis*)

Grizzly bear (*Ursus arctos horribilis*) was first proposed for listing on January 2, 1975, and finalized with an amendment published July 28, 1975 (40 FR 41734); critical habitat was proposed in 1976 (41 FR 48757), but never finalized. Numerous recovery planning and conservation strategy documents have been published since listing. Primary threats contributing to the decline in species distribution and abundance is excessive human-caused mortality and habitat loss. Low reproductive potential, large home range and habitat requirements, and sensitivity to human disturbance contribute to their vulnerability. Grizzly bear habitat typically includes diverse foods, cover, denning habitat, and space for this wide-ranging species.

Grizzly bear populations are known to occur in the Selkirk Mountains in northwest Idaho and extreme northeast Washington, the Cabinet-Yaak mountain ranges in Idaho and Montana, and from the Northern Continental Divide Ecosystem, which includes Glacier National Park and surrounding mountainous areas to the east of Hungry Horse reservoir and the Flathead River. Therefore, it is possible that grizzly bears may occasionally use areas adjacent to Lake Kootenusa and Hungry Horse Reservoir and the associated downstream reaches of the Kootenai River and Flathead River, respectively.

The varial zones of Lake Kootenusa and Hungry Horse Reservoir and often do not contain the habitat elements that are necessary to support grizzly bear, nor are these areas anticipated to become more suitable for grizzly bear in the future. In general, the downstream areas of the Kootenai and Flathead Rivers are lower in elevation and have much greater use by humans than habitat preferred by grizzly bear. Any modification in the amount of exposed varial zone habitat that may occur as a result of implementing the Proposed Action is not expected to change the amount or composition of grizzly bear habitat that may benefit grizzly bear. The same is true for the river reaches downstream of the Libby Dam and Hungry Horse dam, where habitat changes attributable to implementation of the Proposed Action (e.g., riparian forest development) are unlikely to result in meaningful changes in grizzly bear use because most of these areas are highly modified habitats that are generally unsuitable to grizzly bear. Any grizzly bear that uses habitats influenced by CRS water management activities are most likely transient individuals that will not use these areas for extended periods of time. Therefore, the Actions Agencies conclude that the Proposed Action is not likely to adversely affect grizzly bear.

3.5.2.2 Ute's ladies' tresses (*Spiranthes diluvialis*)

A proposal to list Ute ladies'-tresses as threatened was filed with USFWS in November 1990 (55 FR 47347 1990), and the species was listed as threatened in January 1992 (57 FR 2048 1992). No critical habitat is designated for the species and although a recovery plan was prepared, it was never finalized (USFWS 1995). The species usually occurs in small scattered groups and occupies relatively small areas within the riparian systems. Early to mid-seral riparian habitats created and maintained by stream activity within the floodplain appear to be essential to the orchid. Flowering is generally from mid-July through August; however, based on location it may bloom slightly earlier or later.

The primary threats to Ute ladies'-tresses are competition from exotic weeds, vegetation succession, habitat loss through development and modification, mowing during flowering, grazing by livestock, over-collection, and vulnerability to stochastic events due to a slow reproductive rate and scattered distribution of populations (57 FR 2048 1992). Additional threats include loss of pollinators, natural

herbivory, and changes in hydrology and conflicting management with other rare species (Fertig et al. 2005).

Potentially suitable habitat occurs on stabilized gravel bars and/or shoreline areas along the Columbia Rivers that are moist throughout the growing season and inundated early in the growing season. While the species has a wide range across the western United States; within the action area, the plant is currently documented in Washington State, occurring along the Rocky Reach Reservoir on gravel bars adjacent to the Columbia River in Chelan County, Washington (Fertig et al. 2005).

Natural flooding cycles are important for creating new alluvial habitat and for reducing cover of competing plant species for Ute's ladies'-tresses throughout their range, including along the Columbia River (Fertig et al. 2005). While discharge from Chief Joseph Dam influences downstream flows, the water surface elevation in Rocky Reach reservoir is primarily controlled by the operation of Rocky Reach Dam, which is owned and managed by Chelan County Public Utility District. Therefore, it is unlikely that CRS management actions would result in modification of the habitat positively or negatively beyond current conditions. Therefore, the Action Agencies conclude that the Proposed Action is not likely to adversely affect Ute's ladies'-tresses.

3.5.2.3 Streaked horned lark (*Eremophila alpestris strigata*)

Streaked horned larks (SHLA) are considered a genetically distinct evolutionary unit of horned lark found only in Oregon and Washington (Drovetski et al. 2005). The subspecies was originally proposed for listing by the USFWS on 30 October, 2001, and was formally listed as threatened (and critical habitat designated) on October 3, 2013 (78 FR 61452).

The SHLA subspecies is found primarily in prairie-oak habitats and coastal dune communities west of the Cascade Mountains in Washington and Oregon, where the birds prefer sparsely vegetated areas including sandy islands, wet prairies, oak savannahs and grasslands found at airports, and coastal spits. Specific to the Action Area, islands in the Columbia River estuary currently used for dredged material placement activities mimic sandy areas that were historically cleared of vegetation during the spring freshet and annual high flow events in the Columbia River Basin (Stinson 2005) and are important nesting habitat for the species.

Construction of dams throughout the Columbia River Basin, including those associated with the CRS, established a new hydrograph in the Columbia River that differs from historic conditions; however, the Proposed Action will not result in further degradations, and, in fact, is actively operating to more closely mimic historic conditions while ensuring that other authorized purposes, including flood risk management requirements are maintained. However, most SHLA habitat in the Columbia River estuary is situated above the current floodplain and is unlikely to be exposed to current high water events that historically would have reset vegetative succession. These habitats are now generally maintained through the periodic placement of dredged material.

Because most existing SHLA habitat is unlikely to be exposed to high water events, the operations of the CRS are not likely to influence the destruction/creation/maintenance of early successional habitat conditions preferred by SHLA. However, the placement of dredged material from on-going maintenance of the Columbia River Navigation Channel on many of these sites functions to create and maintain an adequate assemblage of early successional habitat within the network of dredged material placement

sites in the lower Columbia River estuary. No individual SHLA, at any life-history stage, is expected to be exposed to any other aspect of the management of the CRS. Therefore, the Actions Agencies conclude the Proposed Action is not likely to adversely affect SHLA or designated SHLA critical habitat.

3.5.2.4 Yellow-billed cuckoo (*Coccyzus americanus*)

The USFWS announced the proposed listing of the western distinct population of yellow-billed cuckoos (*Coccyzus americanus occidentalis*) as threatened under the ESA on October 3, 2013 (78 FR 61622). On August 15, 2014, the Service published the proposed rule to designate critical habitat (79 FR 48548) and on October 3, 2014, the Service officially listed the western distinct population segment of the yellow-billed cuckoo as threatened (79 FR 59992). Critical habitat remains proposed, though none is proposed in Oregon or Washington, and the four units in Idaho are located well away from the CRS action area.

Western Yellow-Billed Cuckoo nests almost exclusively in large patches of brushy, deciduous riparian habitat dominated by cottonwoods and willows. The last confirmed breeding records in Oregon are from the 1940s and in Washington it was in 1923, but likely continued until at least the early 1940s (Wiles and Kalasz 2017). Historically, the western yellow-billed cuckoo was considered rare in the Pacific Northwest and the available data suggests that if yellow-billed cuckoos still breed in Oregon and Washington, the numbers are extremely low with pairs numbering in the single digits. In Idaho and the action area, the yellow-billed cuckoo is a rare visitor and local breeder that occurs in scattered drainages primarily in the southern portion of the state (Taylor 2000; Reynolds and Hinckley 2005).

The USFWS listing (in 2014) concluded that the curtailment and decline in riparian habitat is primarily the result of long-lasting effects from manmade features that alter watercourse hydrology such that the natural processes that sustain riparian habitats are diminished or non-functional. In addition, the encroachment and establishment of non-native species has further degraded the quality of remaining riparian areas. Climate change was also recognized as a critical issue with potentially wide-ranging effects on the species and its habitat; it was suggested that the effects of climate change will exacerbate habitat loss and degradation, invasive species, and wildfire/drought resulting in smaller patch sizes and more isolated breeding areas. Nesting yellow-billed cuckoos are sensitive to patch size and seldom use riparian areas smaller than 100 m x 300 m. For this reason, the USFWS concluded that smaller patch sizes and isolated breeding areas may compound juvenile dispersal and re-occupation of breeding adults. Furthermore, where riparian areas are located in proximity to urban and agricultural areas, the potential for pesticide and herbicide to affect habitat, prey availability, and cuckoos themselves is increasingly high.

Based on the information provided above, it is assumed that very few western yellow-billed cuckoos are present in the region and action area. Considering that breeding was last documented (or assumed to have last occurred) more than 80 years ago (in Oregon and Washington), which is well before the construction of nearly all the CRS facilities, it's safe to presume that habitat conditions for yellow-billed cuckoo within the action area were already heavily degraded prior to operation and maintenance of the CRS. Today, it is unlikely that current operations are actively degrading existing habitat, and it is difficult to predict how riparian habitat will respond (positively or negatively) to implementation of the Proposed Action that attempts to shape the current hydrograph to better reflect historic conditions (to assist downstream migration of juvenile anadromous salmonids) because of the influence of other

anthropogenic pressures in these areas. Therefore, the Actions Agencies conclude the Proposed Action is not likely to adversely affect yellow-billed cuckoo.

3.5.2.5 *Columbian white-tailed deer (Odocoileus virginianus leucurus)*

The Columbian white-tailed deer (CWTD) was originally listed as an endangered species under the ESA in 1973. In 2016, the Columbia River Distinct Population Segment (DPS) of the CWTD was reclassified as “threatened” and a Section 4(d) rule implemented establishing take prohibitions (82 FR 71386). Critical habitat has not been designated for the CWTD. However, the Julia Butler Hansen National Wildlife Refuge was specifically created in 1971 to protect the CWTD. The refuge, located near Cathlamet, Washington, in Wahkiakum County is comprised of over 6,000 acres of pastures, swamps, brushy woodlots and marshes that provides protected habitat for the CWTD.

The CWTD historically inhabited river valleys throughout western Washington and Oregon. Currently, about half the existing Columbia River DPS of CWTD live on the Julia Butler Hansen refuge in Wahkiakum County. The other half (300 to 400 animals) live on private lands along the lower Columbia River in Washington and Oregon, and on Puget Island in the Columbia River. Certain islands and bottomlands within an 18-mile stretch of the lower Columbia River contain most of the known range of the Columbia River DPS.

CWTD tend to stay in the river bottomlands, in areas less than 3 meters (10 feet) elevation. They favor habitat with a diverse native understory of grasses, forbs, and shrubs accompanied by trees over 10 feet tall for cover, but with an open canopy (USFWS 1983). The Columbia River islands within the action area that contain suitable habitat are vegetated with tidal spruce communities consisting of dense forested swamps covered with tall shrubs and scattered with spruce, alder, cottonwood, and willow (USFWS 1983). The primary threat to the Columbian white-tailed deer comes from human developments including brush removal. Other threats include automobile collisions, poaching, barbed-wire entanglement, and competition with livestock (USFWS 1983).

Today, CWTD that occupy historic floodplain habitat are less exposed to the dangers of high water due primarily to the existence of levees, dikes, and upstream dams, all of which reduce the likelihood of flooding the low-lying habitat preferred by CWTD. In general, the management of the CRS does not modify the existing habitats that are used by CWTD and this is likely to continue into the foreseeable future. Therefore, the Actions Agencies conclude the Proposed Action is not likely to adversely affect Columbian white-tailed deer.

3.6 REFERENCES

- 40 FR 41734. 1975. "Amendment Listing the Grizzly Bear of the 48 Conterminous States as a Threatened Species." *Federal Register* 40(145):31734-31736. U.S. Fish and Wildlife Service. Available at https://ecos.fws.gov/docs/federal_register/fr65.pdf.
- 41 FR 48757. 1976. "Endangered and Threatened Wildlife and Plants; Proposed Determination of Critical Habitat for the Grizzly Bear." *Federal Register* 41(215):48757–48759. U.S. Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-1976-11-05/pdf/FR-1976-11-05.pdf>.
- 50 CFR Part 17. 2010. "Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminous United States; Final Rule " U.S. Department of the Interior; Fish and Wildlife Service. Available at <https://www.fws.gov/pacific/bulltrout/pdf/BTCHFR101810.pdf>.
- 55 FR 47347. 1990. "Endangered and Threatened Wildlife and Plants; Proposal to List the Plant *Spiranthes diluvialis* (Ute ladies'-tresses) as a Threatened Species." *Federal Register* 55(219). U.S. Department of the Interior, Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-1990-11-13/pdf/FR-1990-11-13.pdf#page=57>.
- 56 FR 58619. 1991. "Endangered and Threatened Species; Endangered Status for Snake River Sockeye Salmon." *Federal Register*:58619-58624. RIN 0648-AD90. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Available at <https://www.govinfo.gov/content/pkg/FR-1991-11-20/pdf/FR-1991-11-20.pdf#page=137>.
- 57 FR 2048. 1992. "Endangered and Threatened Wildlife and Plants; Final Rule To List the Plant *Spiranthes Diluvlaiis* (Ute Ladies'-Tresses) as a Threatened Species." *Federal Register* 57(12):2048–2056. U.S. Department of the Interior, Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-1992-01-17/pdf/FR-1992-01-17.pdf#page=52>.
- 57 FR 23458. 1992. "Endangered and Threatened Species: Threatened Status for Snake River Spring/Chinook Salmon, Threatened Status for Snake River Fall Chinook Salmon (correction)." *Federal Register* 57(107):23458. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <http://cdn.loc.gov/service/ll/fedreg/fr057/fr057107/fr057107.pdf>.
- 58 FR 19401. 1993. "Endangered and Threatened Wildlife and Plants; 90-Day Finding for a Petition to List the Kootenai River Population of the White Sturgeon." *Federal Register* 58(70):19401–19402. U.S. Department of the Interior, Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-1993-04-14/pdf/FR-1993-04-14.pdf#page=91>.
- 58 FR 36379. 1993. "Endangered and Threatened Wildlife and Plants; Proposed Endangered Status for the Kootenai River Population of the White Sturgeon." *Federal Register* 58(128):36379–36387. U.S. Department of the Interior, Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-1993-07-07/pdf/FR-1993-07-07.pdf#page=89>.
- 58 FR 68543. 1993 (2006 correction). "Designated Critical Habitat; Snake River Sockeye Salmon, Snake River Spring/Summer Chinook Salmon, and Snake River Fall Chinook Salmon." *Federal Register*:68543-68554. National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce. Available at <https://archive.fisheries.noaa.gov/wcr/publications/frn/1993/58fr68543.pdf>.
- 59 FR 45989. 1994. "Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Kootenai River Population of the White Sturgeon." *Federal Register* 59(171):45989.

Department of the Interior, Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-1994-09-06/html/94-21864.htm>.

62 FR 43937. 1997. "Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead." *Federal Register* 62(159). CFR Citations 50 CFR 222, 50 CFR 227, RIN Number 0648-XX65, Docket No. 960730210-7193-02, I.D. 050294D.

64 FR 14307. 1999. "Endangered and Threatened Species; Threatened Status for Three Chinook Salmon Evolutionarily Significant Units (ESUs) in Washington and Oregon, and Endangered Status for One Chinook Salmon ESU in Washington." *Federal Register* 64(56):14307-14328. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-1999-03-24/pdf/FR-1999-03-24.pdf>.

64 FR 14508. 1999. "Endangered and Threatened Species: Threatened Status for Two ESUs of Chum Salmon in Washington and Oregon." *Federal Register* 64(57):14508–14517. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-1999-03-25/pdf/99-6814.pdf#page=1>.

64 FR 14517. 1999. "Endangered and Threatened Species: Threatened Status for Two ESUs of Steelhead in Washington and Oregon." *Federal Register* 64(57):14517-14528. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-1999-03-25/pdf/99-6817.pdf>.

64 FR 57399. 1999. "Designated Critical Habitat: Revision of Critical Habitat for Snake River Spring/Summer Chinook Salmon." *Federal Register* 64(205):57399-57403. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-1999-10-25/pdf/99-27585.pdf>.

70 FR 37160. 2005. "Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs." *Federal Register*:37159-37204. 50 CFR Parts 223 and 224, RIN:0648-AR93. Docket No. 040525161-5155-02I.D. 052104F. National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce. Available at <https://www.govinfo.gov/content/pkg/FR-2005-06-28/pdf/05-12351.pdf#page=2>.

70 FR 52630. 2005. "Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho." *Federal Register* 70(170):52746. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-2005-09-02/pdf/05-16391.pdf>.

70 FR 69903. 2005. "Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales (Final Rule)." *Federal Register* 70(222):69903–69912. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-2005-11-18/pdf/05-22859.pdf#page=1>.

71 FR 834. 2006. "Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead." *Federal Register*:834-862. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.federalregister.gov/documents/2006/01/05/06-47/endangered-and-threatened-species-final-listing-determinations-for-10-distinct-population-segments>.

71 FR 17757. 2006. "Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon " *Federal Register* 71(67):17757–17766.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-2006-04-07/pdf/06-3326.pdf#page=1>.

71 FR 69070. 2006. "Magnuson-Stevens Act Provisions; Fisheries of the Northeastern United States; Northeast Multispecies Fishery; 2006 Georges Bank Cod Fixed Gear Sector Operations Plan and Agreement and Allocation of Georges Bank Cod Total Allowable Catch " *Federal Register* 74(229):69070–69073. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-2006-11-29/pdf/06-9452.pdf#page=1>.

73 FR 39505. 2008. "Endangered and Threatened Wildlife and Plants; Critical Habitat Revised Designation for the Kootenai River Population of the White Sturgeon (*Acipenser transmontanus*)." *Federal Register* 73(132):39505-39523. Department of the Interior, Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-2008-07-09/pdf/E8-15134.pdf>.

74 FR 42605. 2009. "Listing Endangered and Threatened Species: Change in Status for the Upper Columbia River Steelhead Distinct Population Segment." *Federal Register* 74(162):42605-42606. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-2009-08-24/pdf/E9-20315.pdf>.

74 FR 52300. 2009. "Endangered and Threatened Wildlife and Plants: Final Rulemaking To Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon " *Federal Register* 74(195):52300–52351. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available at <https://www.govinfo.gov/content/pkg/FR-2009-10-09/pdf/E9-24067.pdf#page=2>.

78 FR 61452. 2013. "Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Taylor’s Checkerspot Butterfly and Threatened Status for the Streaked Horned Lark." *Federal Register* 192(78):61452–61503. U.S. Department of the Interior; Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-2013-10-03/pdf/2013-23567.pdf#page=2>.

78 FR 61622. 2013. "Endangered and Threatened Wildlife and Plants; Proposed Threatened Status for the Western Distinct Population Segment of the Yellowbilled Cuckoo (*Coccyzus americanus*)." *Federal Register* 78(192):61622–61666. Proposed Rule. U.S. Department of the Interior; Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-2013-10-03/pdf/2013-23725.pdf#page=2>.

79 FR 20802. 2014. "Endangered and Threatened Wildlife; Final Rule To Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service." *Federal Register*:20802-20817. RIN Number 0648-XC65, Docket No. 130501429-4198-02. Department of Commerce, National Oceanic and Atmospheric Administration.

79 FR 48548. 2014. "Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Western Distinct Population Segment of the Yellow Billed Cuckoo " *Federal Register* 79(158):48548–489652. U.S. Department of the Interior; Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-2014-08-15/pdf/2014-19178.pdf#page=2>.

79 FR 59992. 2014. "Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for the Western Distinct Population Segment of the Yellow-billed Cuckoo (*Coccyzus americanus*)." *Federal Register* 79(192). U.S. Department of the Interior; Fish and Wildlife Service. Available at <https://www.govinfo.gov/content/pkg/FR-2014-10-03/pdf/2014-23640.pdf#page=2>.

84 FR 49214. 2019. "Endangered and Threatened Wildlife and Plants; Proposed Rulemaking To Revise Critical Habitat for the Southern Resident Killer Whale Distinct Population Segment." *Federal Register*

84(182):49214-49235. National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce. Available at <https://www.govinfo.gov/content/pkg/FR-2019-09-19/pdf/2019-20166.pdf>.

Abernethy CS, BG Amidan and GF Cada. 2001. *Laboratory studies of the effects of pressure and dissolved gas supersaturation on turbine-passed fish: Final report FY 2000*. PNNL-13470. Richland, WA: Pacific Northwest National Laboratory. DOI: 10.2172/1218152. Available at https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-13470.pdf.

Achord S, PS Levin and RW Zabel. 2003. "Density-dependent mortality in Pacific salmon: the ghost of impacts past?" *Ecology Letters* 6(4):335-342. DOI: 10.1046/j.1461-0248.2003.00438.x.

Achord S, RW Zabel and BP Sandford. 2007. "Migration timing, growth, and estimated parr-to-smolt survival rates of Wild Snake River spring–summer Chinook salmon from the Salmon River Basin, Idaho, to the Lower Snake River." *Transactions of the American Fisheries Society* 136(1):142-154. DOI: 10.1577/T05-308.1.

Allen MJ and GB Smith. 1988. *Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific*. NOAA Technical Report NMFS 66. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Anders P, J Dunnigan, J Flory, G Hoffman, S Ireland, M Neufeld and P Rust. 2014. *A developmental template-based characterization of recruitment failure for endangered Kootenai River white sturgeon, with application to other sturgeon populations*. Report to the Kootenai Tribe of Idaho and the Kootenai River White Sturgeon Recovery Team.

Anderson JJ, KD Ham and J Gosselin. 2012. *Snake River Basin Differential Delayed Mortality Synthesis*. PNWD-4283. Richland, WA: Battelle, Pacific Northwest Division.

Anderson JJ, RA Hinrichsen, C Van Holmes and KD Ham. 2005. *Historical Analysis of PIT Tag Data for Transportation of Fish at Lower Granite, Little Goose, Lower Monumental and McNary Dams - Task 1: Analysis of In-River Environmental Conditions*. PNWD-3514. Richland, WA: Battelle, Pacific Northwest Division. Prepared for the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, WA. Biological Services Contract no. DACW68-02-D-0001, Task Order 0009.

Anglea SM. 1997. *Abundance and food habits of smallmouth bass and distribution of crayfish in lower Granite Reservoir, Idaho-Washington*, Moscow, ID: Master's thesis. University of Idaho.

Antcliffe BL, LE Fidler and IK Birtwell. 2002. *Effect of dissolved gas supersaturation on the survival and condition of juvenile rainbow trout (Oncorhynchus mykiss) under static and dynamic exposure scenarios*. Vancouver, B.C.: Canadian Technical Reports Fisheries and Aquatic Sciences 2370. Fisheries and Oceans Canada. Available at <http://publications.gc.ca/pub?id=9.579311&sl=0>.

Ardren WR, PW DeHaan, CT Smith, EB Taylor, R Leary, CC Kozfkay, L Godfrey, M Diggs, W Fredenberg, J Chan, CW Kilpatrick, MP Small and DK Hawkins. 2011. "Genetic structure, evolutionary history, and conservation units of bull trout in the coterminous United States." *Transactions of the American Fisheries Society* 140(2):506-525.

Backman TWH, AF Evans, MS Robertson and MA Hawbecker. 2002. "Gas bubble trauma incidence in juvenile salmonids in the lower Columbia and Snake Rivers." *North American Journal of Fisheries Management* 22(3):965-972. DOI: 10.1577/1548-8675(2002)022<0965:GBTIJ>2.0.CO;2.

Baker B. 2015. "Email communication to Erin Kuttel regarding bull trout observation in Upper Columbia portion of Lake Roosevelt."

Bare CM, LR Ciepiela, JS Henderson, TM Jones, IA Tattam and JR Ruzycki. 2019. *Escapement and productivity of summer steelhead and spring Chinook salmon in the John Day River, 2018 Annual Report*. Portland, OR: Bonneville Power Administration, Project No. 1998-016-00. Available at <https://www.cbfish.org/document.mvc/viewer/p163749>.

Barracough WE. 1964. "Contribution to the Marine Life History of the Eulachon *Thaleichthys pacificus*." *Journal of the Fisheries Research Board of Canada* 21(5):1333-1337. DOI: 10.1139/f64-112.

Barrows MG, DR Anglin, PM Sankovich, JM Hudson, RC Koch, JJ Skalicky, DA Wills and BP Silver. 2016a. *Use of the Mainstem Columbia and Lower Snake Rivers by Migratory Bull Trout: Data Synthesis and Analyses, Final Report*. Vancouver, WA: U.S. Fish and Wildlife Service (USFWS). Available at https://www.fws.gov/columbiariver/publications/Use%20of%20the%20Mainstem%20Columbia%20and%20Lower%20Snake%20Rivers%20by%20Migratory%20Bull%20Trout%20Final%20Report_04_6_2016.pdf.

Barrows MG, RC Koch, J Johnson, ML Koski and E Bailey. 2016b. *Clackamas River Bull Trout Reintroduction Project, 2015 Annual Report*. U.S. Fish and Wildlife Service (Columbia River Fisheries Program Office, Vancouver, WA) and Oregon Department of Fish and Wildlife (Corvallis, OR).

Bartel R, E Ikonen and H Auvinen. 2001. "Differences in migration pattern and growth of polish and finnish sea trout (*Salmo trutta L.*) released in the same areas." *Archives of Polish Fisheries* 9:105-122.

Barton GJ, RJ Weakland, RL Fosness and ML Williams. 2010. "Characterizing substrate and channel morphology of the Kootenai River White Sturgeon critical habitat, Boundary County, Idaho: analysis for ecosystem restoration." In *Proceedings of the 4th Federal Interagency Hydrologic Modeling Conference and the 9th Federal Interagency Sedimentation Conference*, Las Vegas, NV. Available at [https://acwi.gov/sos/pubs/2nd JFIC/Contents/2D_Barton-Kootenai_Substrate_Morphology_Approved_v1-r.pdf](https://acwi.gov/sos/pubs/2nd%20JFIC/Contents/2D_Barton-Kootenai_Substrate_Morphology_Approved_v1-r.pdf)

Beamesderfer R, P Anders and T Garrison. 2014. *Abundance and survival of the remnant Kootenai River white sturgeon population*. Report prepared for the Kootenai Tribe of Idaho and the Bonneville Power Administration by Cramer Fish Sciences and R2 Consultants. Available at http://www.fishsciences.net/reports/download_report.php?rid=6840

Beamesderfer RC. 1992. "Reproduction and early life history of northern squawfish, *Ptychocheilus oregonensis*, in Idaho's St. Joe River. *Environmental Biology of Fishes* 35:231-241."

Beamesderfer RC and AA Nigro. 1989. *Status, biology, and alternatives for management of walleye in John Day Reservoir: A review*. Portland, OR: Information reports no. 89-2, Oregon Dept. of Fish and Wildlife. Available at <https://nrimp.dfw.state.or.us/CRL/Reports/Info/89-2.pdf>.

Beamesderfer RC and BE Rieman. 1991. "Abundance and distribution of northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River." *Transactions of the American Fisheries Society* 120(4):439-447. Hardcopy: TH's Books, TAFS 120:439. DOI: 10.1577/1548-8659(1991)120<0439:AADONS>2.3.CO;2.

Beamesderfer RCP, DL Ward and AA Nigro. 1996. "Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia and Snake rivers." *Canadian Journal of Fisheries and Aquatic Sciences* 53(12):2898-2908. Hardcopy, TH's Library: CJFAS 53:2898. DOI: 10.1139/f96-225.

Beeman JW and AG Maule. 2006. "Migration depths of juvenile Chinook salmon and steelhead relative to total dissolved gas supersaturation in a Columbia River reservoir." *Transactions of the American Fisheries Society* 135(3):584-594. DOI: 10.1577/T05-193.1.

Beeman JW, DA Venditti, RG Morris, DM Gadomski, BJ Adams, SP Vanderkooi, TC Robinson and AG Maule. 2003. *Gas Bubble Disease in Resident Fish Below Grand Coulee Dam: Final Report of Research*. Boise, ID: U.S. Bureau of Reclamation. Western Fisheries Research Center, Columbia River Research Laboratory, U.S. Geological Survey, Cook, Washington.

Bellerud B. 2018. "Final 2019 BiOp RM&E take tables.xls." Portland, Oregon: National Marine Fisheries Service.

Beyer JM, G. Lucchetti and G Gray. 1988. "Digestive tract evacuation in northern squawfish (*Ptychocheilus oregonensis*). *Canada Journal of Fisheries and Aquatic Sciences* 45:548-553."

BioAnalysts, Inc. 2002. *Movement of bull trout within the Mid-Columbia River and tributaries, 2001-2002 final*. Boise, ID: BioAnalysts Inc. Prepared for Chelan Public Utility District, November 20, 2002.

BioAnalysts, Inc. 2004. *Movement of bull trout within the Mid-Columbia River and tributaries, 2001-2004*. Redmond, WA: BioAnalysts Inc. Prepared for Public Utility District No. 1 of Chelan, WA.

Bisson PA and RE Bilby. 1998. "Organic Matter and Trophic Dynamics." In *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion*, pp. 373-398. eds: RJ Naiman and RE Bilby. New York, NY: Springer-Verlag.

Bjornn TC, DR Craddock and DR Corley. 1968. "Migration and survival of Redfish Lake, Idaho, sockeye salmon, *Oncorhynchus nerka*." *Transactions of the American Fisheries Society* 97(4):360-373. DOI: 10.1577/1548-8659(1968)97[360:MASORL]2.0.CO;2.

Bond MH, PAH Westley, AH Dittman, D Holecek, T Marsh and TP Quinn. 2017. "Combined Effects of Barge Transportation, River Environment, and Rearing Location on Straying and Migration of Adult Snake River Fall-Run Chinook Salmon." *Transactions of the American Fisheries Society* 146(1):60-73. DOI: 10.1080/00028487.2016.1235614.

Bonneville and Corps. 2016. *Columbia Estuary Ecosystem Restoration Program: Final Environmental Assessment*. Portland, OR: Bonneville Power Administration (Bonneville) and U.S. Army Corps of Engineers (Corps). Available at https://www.energy.gov/sites/prod/files/2016/07/f33/EA-2006_FEA-2016.pdf.

Bonneville, Reclamation and Corps. 2017. *Columbia River System Operational and Structural Improvements under the Endangered Species Act – 2017 Progress Update* Bonneville Power Administration (Bonneville), U.S. Bureau of Reclamation (Reclamation), and U.S. Army Corps of Engineers (Corps).

Bonneville, Reclamation and Corps. 2018a. "Appendix D: Columbia River system operational and structural improvements under the Endangered Species Act – 2017 Progress Update." In *ESA Section 7(a)(2) initiation of formal consultation for the operations and maintenance of the Columbia River System on NOAA Fisheries listed species and designated critical habitat*, pp. 181-238. Portland, OR: Bonneville Power Administration (Bonneville), U.S. Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers (Corps).

Bonneville, Reclamation and Corps. 2018b. *ESA Section 7(a)(2) initiation of formal consultation for the operations and maintenance of the Columbia River System on NOAA Fisheries listed species and designated critical habitat*. Portland, OR: Bonneville Power Administration (Bonneville), U.S. Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers (Corps). Available at <https://www.salmonrecovery.gov/doc/default-source/default-document-library/proposedaction2019crs.pdf?status=Temp&sfvrsn=0.29652687684318046>.

Bonneville and Reclamation. 2013. *Benefits of Tributary Habitat Improvement in the Columbia River Basin: Results of Research, Monitoring and Evaluation, 2007–2012*. Bonneville Power Administration (Bonneville) and Bureau of Reclamation (Reclamation).

Bottom DL, CA Simenstad, J Burke, AM Baptista, DA Jay, KK Jones, E Casillas and MH Schiewe. 2005. *Salmon at River's End: The Role of the Estuary In the Decline and Recovery of Columbia River Salmon*. Seattle, WA: U.S. Dept. of Commerce, Northwest Fisheries Science Center. NOAA Technical Memorandum NMFS-MWFSC-68. Available at <https://repository.library.noaa.gov/view/noaa/3432>.

Brannon E, SJ Brewer, A Setter, M Miller, F Utter and W Hershberger. 1985. *Columbia River White Sturgeon (Acipenser Transmontanus) Early Life History and Genertics Study, August 1, 1984 to December 31, 1985 Final Report*. DOE/BP-18952-1. Portland, OR: Bonneville Power Administration. Available at <https://digital.library.unt.edu/ark:/67531/metadc1084975/m1/1/>.

Brosnan IG, DW Welch and M Jacobs Scott. 2016. "Survival rates of out-migrating yearling chinook salmon in the lower Columbia River and plume after exposure to gas-supersaturated water." *Journal of Aquatic Animal Health* 28(4):240-251. DOI: 10.1080/08997659.2016.1227398.

Buchanan RA, JR Skalski, G Mackey, C Snow and AR Murdoch. 2015. "Estimating cohort survival through tributaries for salmonid populations with variable ages at migration." *North American Journal of Fisheries Management* 35(5):958-973. DOI: 10.1080/02755947.2015.1064837.

Buchanan RA, JR Skalski, RL Townsend and KD Ham. 2011. *The effect of bypass passage on adult returns of salmon and steelhead: An analysis of PIT-tag data using the program ROSTER, Final report*. Walla Walla, WA: Report No. PNWD-4241 by Battelle for the U.S. Army Corps of Engineers, Walla Walla District under Contract No. W912EF-08-D-0004 DO4. University of Washington and Battelle. Available at https://www.salmonrecovery.gov/Files/2011%20APR%20files/Corrections/Buchanan_et_al_2011_Bypass_Effects_Final_Report.pdf.

Budy P, GP Thiede, N Bouwes, CE Petrosky and H Schaller. 2002. "Evidence Linking Delayed Mortality of Snake River Salmon to Their Earlier Hydrosystem Experience." *North American Journal of Fisheries Management* 22(1):35-51. DOI: 10.1577/1548-8675(2002)022<0035:ELDMOS>2.0.CO;2.

Busby PJ, TC Wainwright and GJ Bryant. 1996. *Status review of West Coast steelhead from Washington, Idaho, Oregon, and California*. NOAA Technical Memorandum, NMFS-NWFSC-27. U.S. Department of Commerce.

Čada GF. 2001. "The development of advanced hydroelectric turbines to improve fish passage survival." *Fisheries* 26(9):14-23. Hardcopy: TH's Library, FISH 26(9):14. DOI: 10.1577/1548-8446(2001)026<0014:TDOAHT>2.0.CO;2.

Cain ML, WD Bowman and SD Hacker. 2014. *Ecology, Third Edition*, Sunderland, MA: Sinauer Associates, Inc. ISBN 9780878939084.

Caudill CC, ML Keefer, TS Clabough, GP Naughton, BJ Burke and CA Peery. 2013. "Indirect effects of impoundment on migrating fish: Temperature gradients in fish ladders slow dam passage by adult Chinook salmon and steelhead." *PLOS ONE* 8(12):e85586. DOI: 10.1371/journal.pone.0085586.

CBBTTAT. 1998. *North Fork Clearwater River Basin Bull Trout Problem Assessment*. Clearwater Basin Bull Trout Technical Advisory Team (CBBTTAT). Collaborative, multi-agency scientific assessment of bull trout status prepared for the State of Idaho. May 1998.

Chapman D, C Peven, A Giorgi, T Hillman and F Utter. 1995. *Status of spring chinook salmon in the Mid-Columbia region*, Boise, ID: Don Chapman Consultants, Inc.

Chapman DW, C Peven, T Hillman, A Giorgi and F Utter. 1994. *Status of summer steelhead in the Mid-Columbia River*. Boise, ID: Don Chapman Consultants, Inc. Report prepared for the Mid-Columbia Public Utility Districts. Wells Spring Chinook HGMP; Wells Project No. 2149.

Chapman DW, WS Platts, D Park and MT Hill. 1990. *Status of Snake River sockeye salmon. Final report*, Portland, OR: Don Chapman Consultants, Inc., for Pacific Northwest Utilities Conference Committee.

Chisholm I, ME Hensler, B Hansen and D Skaar. 1989. *Quantification of Libby Reservoir Levels Needed to Maintain or Enhance Reservoir Fisheries: summary report 1983-1985*. Portland, OR: U.S. Dept. of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Chittaro P, L Johnson, D Teel, P Moran, S Sol, K Macneale and R Zabel. 2018. "Variability in the performance of juvenile Chinook salmon is explained primarily by when and where they resided in estuarine habitats." *Ecology of Freshwater Fish* 27(3):857-873. DOI: 10.1111/eff.12398.

Cichosz T, D Saul, C Rabe, A Davidson, W Warren, D Rollins, J Willey and T Tate. 2001. *(Draft) FY 2002-2004 Mountain Snake Province Work Plan, Columbia Basin Fish and Wildlife Authority*. Prepared for the Northwest Power Planning Council.

Climate Impacts Group. 2004. *Overview of climate change impacts in the U.S. Pacific Northwest*. Seattle, WA: Background paper prepared for the West Coast Governors' Climate Change Initiative by Climate Impacts Group, University of Washington. Available at <http://cses.washington.edu/db/pdf/cigoverview353.pdf>.

Collis K, A Evans, B Cramer, A Turecek, Q Payton, R Bhatt, T Kaufman, M Gibson and T Lawes. 2019. *Implementation of the Inland Avian Predation Management Plan, 2018 final annual report*. Submitted to the U.S. Army Corps of Engineers, Walla Walla District and U.S. Bureau of Reclamation, IDIQ Contract No. W912EF-14-D-0004, Order No. 0007. Available at http://www.birdresearchnw.org/2018%20IAPMP%20Final%20Report_v5.pdf.

Colotelo AH, RA Harnish, BW Jones, AC Hanson, DM Trott, MJ Greiner, GA McMichael, KD Ham, ZD Deng, RS Brown, MA Weiland, X Li and T Fu. 2014. *Passage Distribution and Federal Columbia River Power System Survival for Steelhead Kelts Tagged Above and at Lower Granite Dam, Year 2*. PNNL-23051, Rev. 1. Richland, WA: Pacific Northwest National Laboratory. Prepared for the U.S. Army Corps of Engineers, Walla Walla District. Available at https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23051Rev.1.pdf.

Colotelo AH, BW Jones, RA Harnish, GA McMichael, KD Ham, ZD Deng, GM Squeochs, RS Brown, MA Weiland, GR Ploskey, X Li and T Fu. 2013. *Passage Distribution and Federal Columbia River Power System Survival for Steelhead Kelts Tagged Above and at Lower Granite Dam: Final Report*. PNNL-22101. Richland, WA: Battelle, Pacific Northwest Division. Prepared for the U.S. Army Corps of Engineers, Walla Walla District, Contract No. W912EF-08-D-0004. Available at https://www.salmonrecovery.gov/Files/Comprehensive%20Evaluation/Colotelo-et-al_2013_%20Kelt-Passage-Distribution-Survival_PNWD-22101.pdf.

Connor WP, HL Burge, JR Yearsley and TC Bjornn. 2003. "Influence of flow and temperature on survival of wild subyearling fall Chinook salmon in the Snake River." *North American Journal of Fisheries Management* 23(2):362-375. Hardcopy: TH's Library, NAJFM 23:362. DOI: 10.1577/1548-8675(2003)023<0362:IOFATO>2.0.CO;2.

Connor WP, JG Sneva, KF Tiffan, RK Steinhorst and D Ross. 2005. "Two alternative juvenile life history types for fall Chinook salmon in the Snake River Basin." *Transactions of the American Fisheries Society* 134(2):291-304. Hardcopy: TH's Library, TAFS 134:291. DOI: 10.1577/T03-131.1.

- Connor WP, KF Tiffan, JM Plumb and CM Moffitt. 2013. "Evidence for density-dependent changes in growth, downstream movement, and size of Chinook salmon subyearlings in a large-river landscape." *Transactions of the American Fisheries Society* 142(5):1453-1468. DOI: 10.1080/00028487.2013.806953.
- Cooney T. 2014. *Snake River Fall Chinook*. PowerPoint presentation to the ISAB. NOAA Fisheries, April 2014.
- Copeland T and DA Venditti. 2009. "Contribution of three life history types to smolt production in a Chinook salmon (*Oncorhynchus tshawytscha*) population." *Canadian Journal of Fisheries and Aquatic Sciences* 66(10):1658-1665. DOI: 10.1139/f09-110.
- Copeland T, DA Venditti and BR Barnett. 2014. "The importance of juvenile migration tactics to adult recruitment in stream-type Chinook salmon populations." *Transactions of the American Fisheries Society* 143(6):1460-1475. DOI: 10.1080/00028487.2014.949011.
- Corps. 1999. *Kootenai Flood Control Study Analysis of Local Impacts of the Proposed VARQ Flood Control Plan. Status Report. Work to Date on the Development of the VARQ Flood Control Operation at Libby Dam and Hungry Horse Dam. Section 2*. U.S. Army Corps of Engineers (Corps).
- Corps. 2013a. *East Sand Island Caspian Tern Predation Management Plan*. Portland, OR: U.S. Army Corps of Engineers (Corps).
- Corps. 2013b. *Location and Use of Adult Salmon Thermal Refugia in the Lower Columbia and Lower Snake Rivers, Federal Columbia River Power System Amendment 1 of the Supplemental FCRPS BiOp*. Portland, OR: U.S. Army Corps of Engineers (Corps), Northwestern Division.
- Corps. 2014a. *Inland Avian Predation Management Plan*. Walla Walla, WA: U.S. Army Corps of Engineers (Corps), Walla Walla District, Northwestern Division. Available at <https://www.nww.usace.army.mil/Missions/Projects/Inland-Avian-Predation-Management-Plan/>.
- Corps. 2014b. *Inland Avian Predation Management Plan: Environmental Assessment*. Walla Walla, WA: U.S. Army Corps of Engineers (Corps), Walla Walla District. Available at https://www.nww.usace.army.mil/Portals/28/docs/programsandprojects/IAPMP/Final_IAPMP_EA_Fullpackage%20vs1.pdf.
- Corps. 2015a. *Caspian Tern Nesting Habitat Management East Sand Island, Clatsop County, Oregon, Final Environmental Assessment*. Portland, OR: U.S. Army Corps of Engineers (Corps), Portland District, Northwestern Division.
- Corps. 2015b. *Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary*. Portland, OR: U.S. Army Corps of Engineers (Corps). Available at https://www.aphis.usda.gov/regulations/pdfs/nepa/OR_DCCO%20FEIS%20ESI%20Feb%206%202015.pdf.
- Corps. 2015c. *Transportation of Juvenile Salmonids, Configuration and Operations Plan (Draft)*. Walla Walla, WA: U.S. Army Corps of Engineers (Corps), Walla Wall District.
- Corps. 2016. *2016 Fish Passage Plan*. CENWD-PDW-R. U.S. Army Corps of Engineers (Corps), Northwestern Division, Lower Columbia & Lower Snake River Hydropower Projects.
- Corps, Reclamation and Bonneville. 2017a. *Endangered Species Act Federal Columbia River Power System 2016 comprehensive evaluation - section 1*. Portland, OR: U.S. Army Corps of Engineers (Corps) Northwestern Division; Bureau of Reclamation (Reclamation) Pacific Northwest Region; Bonneville Power Administration (Bonneville). Available at

<https://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/fcrps-2016-comprehensive-evaluation>.

Corps, Reclamation and Bonneville. 2017b. *Endangered Species Act Federal Columbia River Power System 2016 comprehensive evaluation: section 2. Detailed description of Reasonable and Prudent Alternative (RPA) action implementation*. Portland, OR: U.S. Army Corps of Engineers (Corps), Northwestern Division; Bureau of Reclamation (Reclamation), Pacific Northwest Region; Bonneville Power Administration (Bonneville). Available at

<https://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/fcrps-2016-comprehensive-evaluation>.

Craig SD and RC Wissmar. 1993. *Habitat conditions influencing a remnant bull trout spawning population, Gold Creek, Washington (Draft)*. Seattle, WA: Fisheries Research Institute, University of Washington.

Cramer BM, AF Evans, Q Payton, K Collis and DD Roby. In preparation. "Relative Impacts of Double-crested Cormorants and Caspian Terns on Juvenile Salmonids in the Columbia River Estuary: A Retrospective Analysis of Predation Based on Colony Locations."

Crozier L, E Dorfmeier, T Marsh, B Sandford and D Widener. 2016. *Refining our understanding of early and late migration of adult Upper Columbia spring and Snake River spring/summer Chinook salmon: passage timing, travel time, fallback and survival*. Seattle, WA: Northwest Fisheries Science Center, National Marine Fisheries Service. Available at

https://www.nwfsc.noaa.gov/assets/11/9043_02102017_113115_Crozier%20et%20al%202016%20Chinook%20adult%20mig%20timing%20survival-Mar08_2016.pdf.

Crozier L, E Dorfmeier, B Sandford and B Burke. 2015. *Passage and survival of adult Snake River sockeye salmon within and upstream from the Federal Columbia River Power System: 2014 update*. Walla Walla, WA: Report by Northwest Fisheries Science Center for the U.S. Army Corps of Engineers, Walla Walla District. Available at

https://www.nwfsc.noaa.gov/assets/26/9046_02102017_141813_Crozier%20et%20al%202015%20Sockeye_2008_2014.pdf.

Crozier LG, BJ Burke, BP Sandford, GA Axel and BL Sanderson. 2014. *Passage and survival of adult Snake River sockeye salmon within and upstream from the Federal Columbia River Power System*. Walla Walla, WA: Report by Northwest Fisheries Science Center for the U.S. Army Corps of Engineers, Walla Walla District. Available at <https://www.columbiariverkeeper.org/sites/default/files/2017/08/7.pdf>.

Crozier LG, MM McClure, T Beechie, SJ Bograd, DA Boughton, M Carr, TD Cooney, JB Dunham, CM Greene, MA Haltuch, EL Hazen, DM Holzer, DD Huff, RC Johnson, CE Jordan, IC Kaplan, ST Lindley, NJ Mantua, PB Moyle, JM Myers, MW Nelson, BC Spence, LA Weitkamp, TH Williams and E Willis-Norton. 2019. "Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem." *PLOS ONE* 14(7):e0217711. DOI: 10.1371/journal.pone.0217711.

CTCR. 2000. *Colville Indian Reservation Integrated Resource Management Plan 2000-2014. Final Environmental Impact Statement*. Nespelam, WA: Confederated Tribes of the Colville Reservation (CTCR).

Daly EA, JA Scheurer, RD Brodeur, LA Weitkamp, BR Beckman and JA Miller. 2014. "Juvenile steelhead distribution, migration, feeding, and growth in the Columbia River estuary, plume, and coastal waters." *Marine and Coastal Fisheries* 6(1):62-80. DOI: 10.1080/19425120.2013.869284.

DART. 2019. "Columbia River DART (Data Access in Real Time): 2011 Spring Chinook detected at Bonneville Adult Fish Ladders." Accessed March 25, 2019. Available at http://www.cbr.washington.edu/dart/wrapper?type=php&fname=pitfallback_1553541868_303.php.

DeHaan P and BJ Adams. 2011. *Analysis of genetic variation and assessment of population assignment methods for Lewis River bull trout*. Longview, WA: U.S. Fish and Wildlife Service, Abernathy Fish Technology Center.

DeHaan P and WR Ardren. 2007. *Genetic analysis of bull trout in the Deadwood and Payette rivers, Idaho; Phase II Final genetics report*. Longview, WA: Abernathy Fish Technology Center, U.S. Fish and Wildlife Service.

DeHaan PW, WR Ardren and D Campton. 2005. *Genetic Analysis of Hybridization between Bull Trout and Brook Trout in the upper Malheur River Basin, Oregon*. USFWS Final Report.

DeHart M. 2012. *Fish Passage Center: 2011 Annual Report*. Portland, OR: Fish Passage Center of the Columbia Basin Fish & Wildlife Authority. Available at http://www.fpc.org/documents/FPC_Annual_Reports.html.

DeHart M. 2018. *Fish Passage Center: 2017 Annual Report*. Portland, OR: Fish Passage Center of the Columbia Basin Fish & Wildlife Authority. Available at http://www.fpc.org/documents/FPC_Annual_Reports.html.

DeHart M. 2019. *Fish Passage Center, 2018 Annual Report*. Portland, OR: Fish Passage Center of the Columbia Basin Fish & Wildlife Authority. Available at http://www.fpc.org/documents/FPC_Annual_Reports.html.

Di Lorenzo E, N Schneider, KM Cobb, PJS Franks, K Chhak, AJ Miller, JC McWilliams, SJ Bograd, H Arango, E Curchitser, TM Powell and P Rivière. 2008. "North Pacific Gyre Oscillation links ocean climate and ecosystem change." *Geophysical Research Letters* 35(8). DOI: 10.1029/2007GL032838.

Diefenderfer HL, AB Borde, IA Sinks, VI Cullinan and SA Zimmerman. 2016. *Columbia Estuary Ecosystem Restoration Program: Restoration Design Challenges for Topographic Mounds, Channel Outlets, and Reed Canarygrass*. PNNL-24676. Richland, WA: Pacific Northwest National Laboratory. Final report prepared for the Bonneville Power Administration, Portland, Oregon by the Pacific Northwest National Laboratory, Sequim, Washington and Columbia Land Trust, Vancouver, Washington.

Diefenderfer HL, GE Johnson, RM Thom, AB Borde, CM Woodley, LA Weitkamp, KE Buenau and RK Kropp. 2013. *An evidence-based evaluation of the cumulative effects of tidal freshwater and estuarine ecosystem restoration on endangered juvenile salmon in the Columbia River*. PNNL-23037. Final report prepared for the U.S. Army Corps of Engineers Portland District, Portland, Oregon, by Pacific Northwest National Laboratory and NOAA Fisheries, Richland, Washington. Available at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23037.pdf.

Dietrich J, K Eder, D Thompson, R Buchanan, J Skalski, G McMichael, D Fryer and F Loge. 2016. "Survival and transit of in-river and transported yearling Chinook salmon in the lower Columbia River and estuary." *Fisheries Research* 183:435-446. DOI: 10.1016/j.fishres.2016.07.005.

Dietrich JP, DA Boylen, DE Thompson, EJ Loboschefskey, CF Bravo, DK Spangenberg, GM Ylitalo, TK Collier, DS Fryer, MR Arkoosh and FJ Loge. 2011. "An Evaluation of the Influence of Stock Origin and Out-migration History on the Disease Susceptibility and Survival of Juvenile Chinook Salmon." *Journal of Aquatic Animal Health* 23(1):35-47. DOI: 10.1080/08997659.2011.568859.

Dinsmore SJ, P Rust, R Hardy, TJ Ross, S Stephenson and S Young. 2015. *Kootenai River Juvenile White Sturgeon Population Analysis. Final Report*. Subcontract for Kootenai River Resident Fish Mitigation Program.

Douglas County PUD. 2014. *Bull Trout Monitoring and Management Plan 2013 Annual Report*. Wells Hydroelectric Project. FERC Project No. 2149. Public Utilities District No. 1 of Douglas County, East Wenatchee, WA.

Drovetski SV, SF Pearson and S Rohwer. 2005. "Streaked horned lark *Eremophila alpestris strigata* has distinct mitochondrial DNA." *Conservation Genetics* 6(6):875-883. DOI: 10.1007/s10592-005-9074-9.

Dunnigan J. 2015. *Mitigation for the Construction and Operation of Libby Dam Annual Report 2015*. BPA Project # 1995-004-00.

Dunnigan JL, J DeShazer, T Ostrowski, M Benner, J Lampton, L Garrow and M Boyer. 2017. *Mitigation for the Construction and Operation of Libby Dam, 1/1/2016-12/31/2016 Annual Report*. BPA Project # 1995-004-00. Libby, MT: Montana Fish, Wildlife and Parks. Available at <https://www.cbfish.org/Document.mvc/Viewer/P154535>.

Ecovista, Nez Perce Tribe Wildlife Division and WSU Center for Environmental Education. 2003. *Draft—Clearwater subbasin assessment. Northwest Power and Conservation Council Rep*. Prepared for Nez Perce Tribe Watersheds Division, Idaho Soil Conservation Commission. Available at <https://www.nwcouncil.org/sites/default/files/assessment.pdf>.

Eder K, D Thompson, R Buchanan, J Heublein, J Groff, J Dietrich, J Skalski, C Peery, M Arkoosh, T Collier and F Loge. 2009. *Survival and travel times of in-river and transported yearling Chinook salmon in the lower Columbia River and estuary with investigation into causes of differential mortality* Study Code: BPS-00-10, SPE-06-2. Final Report Submitted to Army Corps of Engineers, Walla Walla District

Available at https://www.salmonrecovery.gov/Files/Comprehensive%20Evaluation/Eder-et-al_2009_LCRE-2008-Survival-JSATs.pdf.

Elder T, CM Woodley, MA Weiland and AL Strecker. 2016. "Factors influencing the survival of outmigrating juvenile salmonids through multiple dam passages: an individual-based approach." *Ecology and Evolution* 6(16):5881-5892. DOI: 10.1002/ece3.2326.

EPA. 2003. *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards*. EPA 910-B-03-002. Seattle, WA: U.S. Environmental Protection Agency (EPA), Region 10 Office of Water. Available at <https://nepis.epa.gov/Exe/ZyPDF.cgi/P1004IUI.PDF?Dockey=P1004IUI.PDF>.

Erhardt JM, KF Tiffan and WP Connor. 2018. "Juvenile Chinook salmon mortality in a Snake River reservoir: Smallmouth bass predation revisited." *Transactions of the American Fisheries Society* 147(2):316-328. DOI: 10.1002/tafs.10026.

ERTG. 2019. *Landscape Principles for CEERP Restoration Strategy*. ERTG 2017-02. Portland, OR: Expert Regional Technical Group (ERTG). Prepared for the Bonneville Power Administration, U.S. Army Corps of Engineers, and NOAA Fisheries. Available at <https://www.cbfish.org/FileResource.mvc/DownloadPdfFileResource/61203df8-9ba3-4b71-bec9-ee1afc687489>.

Evans A, Q Payton, B Cramer, K Collis, D Roby and A Turecek. In preparation. *Avian Predation Synthesis Report: Predation Rate Methods and Results for Inclusion in Appendix A and B*. Prepared for the U.S. Army Corps of Engineers, Bonneville Power Administration, Grant County Public Utility District, and Oregon Department of Fish and Wildlife.

- Evans AF, NJ Hostetter, K Collis, DD Roby and FJ Loge. 2014. "Relationship between Juvenile Fish Condition and Survival to Adulthood in Steelhead." *Transactions of the American Fisheries Society* 143(4):899-909. DOI: 10.1080/00028487.2014.901248.
- Evans AF, NJ Hostetter, DD Roby, K Collis, DE Lyons, BP Sandford, RD Ledgerwood and S Sebring. 2012. "Systemwide evaluation of avian predation on juvenile salmonids from the Columbia River based on recoveries of passive integrated transponder tags." *Transactions of the American Fisheries Society* 141(4):975-989. DOI: 10.1080/00028487.2012.676809.
- Evans AF, Q Payton, BM Cramer, K Collis, NJ Hostetter, DD Roby and C Dotson. 2019. "Cumulative effects of avian predation on Upper Columbia River steelhead." *Transactions of the American Fisheries Society* 148(5):896-913. DOI: 10.1002/tafs.10197.
- Evans AF, Q Payton, BM Cramer, K Collis, J Tennyson, PJ Loschl and DE Lyons. 2018. *East Sand Island passive integrated transponder tag recovery and avian predation rates analysis, 2017*. Portland, OR: Final Technical Report submitted to the U.S. Army Corps of Engineers in partial fulfillment of Contract No. W912EF-14-D-0004, Order No. W9127NF0014. Available at <http://www.birdresearchnw.org/2017%20ESI%20PIT%20Recovery%20Final%20Reportv2.pdf>.
- Evans AF, Q Payton, A Turecek, B Cramer, K Collis, DD Roby, PJ Loschl, L Sullivan, J Skalski, M Weiland and C Dotson. 2016. "Avian predation on juvenile salmonids: spatial and temporal analysis based on acoustic and passive integrated transponder tags." *Transactions of the American Fisheries Society* 145(4):860-877. DOI: 10.1080/00028487.2016.1150881.
- Evans SD, CE Walker, SJ Brewer and NS Adams. 2010. *Assessing survival of Mid-Columbia River released juvenile salmonids at McNary Dam, Washington, 2008–09*, Portland, OR: U.S. Geological Survey Open-File Report 2010-1237. Prepared in cooperation with the U.S. Army Corps of Engineers.
- Faler MP, L.M. Miller and KI Welke. 1988. "Effects of variation in flow on distribution of northern squawfish in the Columbia River below McNary Dam. *North American Journal of Fisheries Management* 8:30-35."
- Falter CM. 1969. "Digestive rates and daily rations of northern squawfish in the St. Joe River, Idaho. Doctoral dissertation, University of Idaho, Moscow."
- Fang C, L Wu and X Zhang. 2014. "The impact of global warming on the pacific decadal oscillation and the possible mechanism." *Advances in Atmospheric Sciences* 31(1):118-130. 2 page preview only. DOI: 10.1007/s00376-013-2260-7.
- Farley Jr. EV, TD Beacham and AV Bugaev. 2018. "Ocean ecology of Sockeye Salmon." In *Ocean ecology of pacific salmon and trout*, pp. 319-389. ed: RJ Beamish. Ch. 3. Bethesda, Maryland: American Fisheries Society. Hardcopy: TH's Library; PDF also purchased through AFS: full book EC-14263, chapters EC-14243 through EC-14262.
- Faulkner JR, BL Bellerud, DL Widener and RW Zabel. 2019. "Associations among fish length, dam passage history, and survival to adulthood in two at-risk species of Pacific salmon." *Transactions of the American Fisheries Society* 148(6):1069-1087. DOI: 10.1002/tafs.10200.
- Federal Caucus. 2000. *Conservation of Columbia Basin Fish: Final Basinwide Salmon Recovery Strategy*, Portland, OR: Federal Caucus. Available at <https://catalog.hathitrust.org/Record/102422376>.
- Fertig W, R Black and P Wolken. 2005. *Rangewide Status Review of Ute Ladies'- Tresses (Spiranthes diluvialis)*. Prepared for U.S. Fish & Wildlife Service and Central Utah Water Conservancy District.

Available at

<https://efotg.sc.egov.usda.gov/references/public/WY/UtesRangewideStatusReview2005byFertig.pdf>.

Fish FF and MG Hanavan. 1948. *A Report Upon the Grand Coulee Fish Maintenance Project 1939-1947*. Special Scientific Report - Fisheries 55. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service. Available at <https://pubs.er.usgs.gov/publication/70160508>.

Fisher JL, WT Peterson and RR Rykaczewski. 2015. "The impact of El Niño events on the pelagic food chain in the northern California Current." *Global Change Biology* 21(12):4401-4414. DOI: 10.1111/gcb.13054.

Flory JE. 2011. *Status Review for Kootenai River White Sturgeon (Acipenser transmontanus)*. Spokane, WA: U.S. Fish and Wildlife Service, Region 1.

Ford MJ. 2002. "Selection in captivity during supportive breeding may reduce fitness in the wild." *Conservation Biology* 16(3):815-825. DOI: 10.1046/j.1523-1739.2002.00257.x.

Ford MJ, Ed. 2011. *Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest*. Seattle, WA: U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NWFSC-113.

FPC. 2018. *Fish Passage Center 2017 Annual Report* Portland, OR: Fish Passage Center (FPC). Contract No. 74404, Project No. 1994-033-00, 1/1/17 to 12/31/17. Bonneville Power Administration. Available at <https://www.cbfish.org/Document.mvc/Viewer/P161914>.

FPC. 2019. "Appendix J: Gas bubble trauma monitoring and data reporting for 2018." In *2018 Total Dissolved Gas Report*, p. 27. ed: U.S. Army Corps of Engineers Northwestern Division. Portland, OR: Fish Passage Center (FPC).

Fraley JJ and BB Shepard. 1989. "Life History, Ecology, and Population Status of Migratory Bull Trout (*Salvelinus confluentus*) in the Flathead Lake and River System." *Northwest Science* 63(4):133-143.

Frederiksen CR, D.E. Fast, W.J. Bosch, GMT and Z Mays. 2019. "Yakima Steelhead VSP Project: Yakima River Steelhead Population Status & Trends Monitoring, 01/01/2018 –12/31/2018 Annual Report, 2010-030-00 <https://www.cbfish.org/Document.mvc/Viewer/P164724>."

Fresh KL, E Casillas, LL Johnson and DL Bottom. 2005. *Role of the estuary in the recovery of Columbia River basin salmon and steelhead: an evaluation of the effects of selected factors on salmonid population viability*, Seattle, WA: U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NWFSC-69.

Fritts AL and TN Pearsons. 2004. "Smallmouth bass predation on hatchery and wild salmonids in the Yakima River, Washington." *Transactions of the American Fisheries Society* 133(4):880-895. Hardcopy in TH's Library: TAFS 133:880. DOI: 10.1577/T03-003.1.

Gadomski DM, M.G. Mesa and TM Olson. 1994. "Vulnerability to predation and physiological stress responses of experimentally descaled juvenile Chinook salmon, *Oncorhynchus tshawytscha*. *Environmental Biology of Fishes* 39:191-199."

Garcia AP, S Bradbury, B Arnsberg and P Groves. 2010. *Fall Chinook salmon spawning ground surveys in the Snake River Basin upriver of Lower Granite Dam, 2009: Annual report*, Portland, OR: Prepared for the Bonneville Power Administration, Project No. 1998-010-03, Contract No. 45097, Doc. P118910.

GCPUD. 2014. *2014 Bull trout monitoring and evaluation report for the Priest Rapids Project*. Grant County, WA: Public Utility District No. 2 of Grant County (GCPUD).

- GEI. 2009. *Cabinet Gorge and Noxon Rapids 145 Upstream Fish Passage, Expert Fish Passage Panel Findings and Recommendations – Final Report*. GEI Consultants (GEI) for Avista Corp.
- Geist DR, TJ Linley, V Cullinan and Z Deng. 2013. "The Effects of Total Dissolved Gas on Chum Salmon Fry Survival, Growth, Gas Bubble Disease, and Seawater Tolerance." *North American Journal of Fisheries Management* 33(1):200-215. DOI: 10.1080/02755947.2012.750634.
- Glick P, J Clough and B Nunley. 2007. *Sea-level rise and coastal habitats in the Pacific Northwest: An analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon*, Seattle, WA: National Wildlife Federation. 106.
- Good TP, RS Waples and P Adams, Eds. 2005. *Updated status of federally listed ESUs of West Coast salmon and steelhead*. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66.
- Gosselin JL and JJ Anderson. 2017. "Combining Migration History, River Conditions, and Fish Condition to Examine Cross-Life-Stage Effects on Marine Survival in Chinook Salmon." *Transactions of the American Fisheries Society* 146(3):408-421. DOI: 10.1080/00028487.2017.1281166.
- Gosselin JL, C Van Holmes, S Iltis and JJ Anderson. 2018a. *Snake River Juvenile Salmon and Steelhead Transportation Synthesis Report*. Columbia Basin Research, School of Aquatic and Fishery Sciences, University of Washington. Report for Division of Fish and Wildlife, Bonneville Power Administration, U.S. Department of Energy. Project No. 1989-108-00; Contract No. 74063 and 77308 Available at <http://www.cbr.washington.edu/sites/default/files/papers/Transportation%20Synthesis%20Report%20FINAL%202018-04-03.pdf>.
- Gosselin JL, RW Zabel, JJ Anderson, JR Faulkner, AM Baptista and BP Sandford. 2018b. "Conservation Planning for Freshwater–Marine Carryover Effects on Chinook Salmon Survival." *Ecology and Evolution* 8(1):319-332. DOI: 10.1002/ece3.3663.
- Gray GA and DW Rondorf. 1986. "Predation on juvenile salmonids in Columbia Basin reservoirs. Pages 178-185 in G.E. Hall and M.J. Van Den Avyle, editors. Reservoir fisheries management strategies from the '80s. American Fisheries Society, Southern Division, Bethesda, Maryland."
- Gregory RS and CD Levings. 1998. "Turbidity reduces predation on migrating juvenile Pacific salmon." *Transactions of the American Fisheries Society* 127(2):275-285. Hardcopy: TH's Library, TAFS 127:275. DOI: 10.1577/1548-8659(1998)127<0275:TRPOMJ>2.0.CO;2.
- Gresh T, J Lichatowich and P Schoonmaker. 2000. "An estimation of historic and current levels of salmon production in the Northeast Pacific ecosystem: Evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest." *Fisheries* 25(1):15-21. DOI: 10.1577/1548-8446(2000)025<0015:AEOHAC>2.0.CO;2.
- Gustafson RG, MJ Ford, DJ Teel and JS Drake. 2010. *Status review of eulachon (Thaleichthys pacificus) in Washington, Oregon, and California*. NOAA Technical Memorandum NMFS-NWFSC-105. Seattle, WA: U.S. Dept. of Commerce, NOAA Fisheries. Available at https://www.nwfsc.noaa.gov/assets/25/1093_06162010_142619_EulachonTM105WebFinal.pdf.
- Haeseker S. 2014. "Nonrepresentative fish and ocean migration assumptions confound inferences in Rechisky et al." *Proceedings of the National Academy of Sciences of the United States of America* 110(37):E3464. DOI: 10.1073/pnas.1309087110.
- Haeseker S, J McCann, B Chockley and D Benner. "Factors Associated with the Regional Patterns of Steelhead Survival in the Columbia River Basin." Presented at *Pacific Coast Steelhead Management Meeting*, March 20-22, 2018, Walla Walla, WA.

Haeseker SL, JA McCann, J Tuomikoski and B Chockley. 2012. "Assessing freshwater and marine environmental Influences on life-stage-specific survival rates of Snake River spring–summer Chinook salmon and steelhead." *Transactions of the American Fisheries Society* 141(1):121-138. DOI: 10.1080/00028487.2011.652009.

Ham KD, PS Titzler, RP Mueller and DM Trott. 2012a. *Hydroacoustic Evaluation of Adult Steelhead Fallback and Kelt Passage at McNary Dam, Winter 2010-2011*. PNWD-4154. Richland, WA: Battelle, Pacific Northwest Division. Final report submitted to the U.S. Army Corps of Engineers, Walla Walla District.

Ham KD, PS Titzler, RP Mueller and DM Trott. 2012b. *Hydroacoustic Evaluation of Adult Steelhead Fallback and Kelt Passage at McNary Dam, Winter 2011-2012*. PNWD-4362. Richland, WA: Battelle, Pacific Northwest Division. Final report submitted to the U.S. Army Corps of Engineers, Walla Walla District.

Hansel HC, JG Romine and RW Perry. 2017. *Acoustic tag detections of green sturgeon in the Columbia River and Coos Bay estuaries, Washington and Oregon, 2010–11: U.S. Geological Survey Open-File Report 2017-114*. Reston, VA: U.S. Geological Survey. DOI: <https://doi.org/10.3133/ofr20171144>.

Hanson AC, AB Borde, LL Johnson, T Peterson, JA Needoba, SA Zimmerman, M Schwartz, CL Wright, PM Chittaro, SY Sol, DJ Teel, GM Ylitalo, D Lomax, CE Tausz, HL Diefenderfer and CC Corbett. 2015. *Lower Columbia River Ecosystem Monitoring Program Annual Report for Year 10 (October 1, 2013 to September 30, 2014)*. Portland, OR: Lower Columbia Estuary Partnership. Prepared for the Bonneville Power Administration. Available at <https://www.estuarypartnership.org/resource/lower-columbia-river-ecosystem-monitoring-program-annual-report-year-10-october-1-2013>.

Hanson J, E Schriever and J Erhardt. 2014. *Bull trout life history investigations in the North Fork Clearwater Basin. Final Report*. Boise, ID: Idaho Department of Fish and Game.

Hanson JT, TL Schultz and RW Carmichael. 2010. *Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River Basin: Annual report 2009*. Portland, OR: Oregon Dept. of Fish and Wildlife. Prepared for the Bonneville Power Administration, Project No. 1989-024-01, Contract No. 45075. Available at <https://www.cbfish.org/Contract.mvc/AgreementDocuments/45075~32213>.

Hardy RS and K McDonnell. 2019. *Kootenai River resident Fish Mitigation: White Sturgeon Adult Population Update (Unpublished)*. BPA Project #1988-065-00. Idaho Department of Fish and Game. Unpublished interim progress report to U.S. Fish and Wildlife Service. August 20, 2019.

Harnish RA, ED Green, CR Vernon and GA McMichael. 2014. *Ecological interactions between hatchery summer steelhead and wild *Oncorhynchus mykiss* in the Willamette River basin, 2014*. Prepared by Pacific Northwest National Laboratory, PNNL-23891, for the U.S. Department of Energy under Contract No. DE-AC05-76RL01830. DOI: 10.2172/1167313. Available at https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23891.pdf.

Hart JL and JL McHugh. 1944. *The Smelts (Osmeridae) of British Columbia*, Ottawa, Canada: Fisheries Research Board of Canada. Bulletin No. 64.

Hatfield T, S McAdam and T Nelson. 2004. *Impacts to abundance and distribution of Fraser River white sturgeon*. Prepared for Fraser River Sturgeon Conservation Society and Fraser River White Sturgeon Working Group.

Hauer FR, H Locke, VJ Dreitz, M Hebblewhite, WH Lowe, CC Muhlfeld, CR Nelson, MF Proctor and SB Rood. 2016. "Gravel-bed river floodplains are the ecological nexus of glaciated mountain landscapes." *Science Advances* 2(6):e1600026. DOI: 10.1126/sciadv.1600026.

- Hay D and PB McCarter. 2000. *Status of the eulachon Thaleichthys pacificus in Canada*. Nanaimo, B.C., Canada: Fisheries and Oceans Canada. Available at <https://www.semanticscholar.org/paper/Status-of-the-eulachon-Thaleichthys-pacificus-in-Hay/88c3bafde2f79a34929661226730254d3ea16e2a>.
- Healey MC. 1991. "Life history of Chinook salmon (*Oncorhynchus tshawytscha*).". In *Pacific salmon life histories*, pp. 311-393. eds: C Groot and L Margolis. Vancouver, BC, Canada: UBC Press.
- Hillman T, M Miller, C Willard, S Hopkins, M Johnson, M Hughes, C Moran, J Williams, M Tonseth, J Caisman, T Pearsons and P Graf. 2019. *Monitoring and evaluation of the Chelan and Grant County PUD's hatchery programs: 2018 annual report*. Wenatchee and Ephrata, WA: Report to the HCP Hatchery Committee and PRCC Hatchery Sub-Committee. BioAnalysts, Inc. Report.
- Hillman T, P Roni and J O'Neal. 2016. *Effectiveness of tributary habitat enhancement projects*. Report to Bonneville Power Administration. Available at <https://www.ucsr.org/?mdocs-file=2322>.
- Hinrichsen RA and CM Paulsen. 2019. "A Multistage Gompertz Life Cycle Model Applied to Threatened Salmon." In *2019 Joint Annual Conference of the American Fisheries Society and the Wildlife Society*, Reno, Nevada. Abstract available at <https://afs.confex.com/afs/2019/meetingapp.cgi/Paper/40230>.
- Hoffman G, BL Marotz and J Dunnigan. 2002. *Mitigation for the Construction and Operation of Libby Dam, 2000 Annual Report*. DOE/BP-00006294-1. Portland, OR: Montana Fish, Wildlife, and Parks. DOI: 10.2172/807637.
- Holsman KK, MD Scheuerell, E Buhle and R Emmett. 2012. "Interacting Effects of Translocation, Artificial Propagation, and Environmental Conditions on the Marine Survival of Chinook Salmon from the Columbia River, Washington, U.S.A." *Conservation Biology* 26(5):912-922. DOI: 10.1111/j.1523-1739.2012.01895.x.
- Honeycutt K. 2014. "Email communication regarding bull trout observations in Sheep Creek in 2012."
- Hostetter NJ, AF Evans, BM Cramer, K Collis, DE Lyons and DD Roby. 2015. "Quantifying Avian Predation on Fish Populations: Integrating Predator-Specific Deposition Probabilities in Tag Recovery Studies." *Transactions of the American Fisheries Society* 144(2):410-422. DOI: 10.1080/00028487.2014.988882.
- Howell MD, MD Romano, TA Rien, ODFW and WSDFW. 2001. *Outmigration Timing and Distribution of Larval Eulachon, Thaleichthys pacificus, in the Lower Columbia River, Spring 2001*. Oregon Department of Fish and Wildlife (ODFW), Clackamas, OR; Washington (State) Department of Fish and Wildlife (WSDFW), Vancouver, WA.
- Hoyle GM, C Holderman, PJ Anders, B Shafii and KI Ashley. 2014. "Water Quality, Chlorophyll, and Periphyton Responses to Nutrient Addition in the Kootenai River, Idaho." *Freshwater Science* 33(4):1024-1029. DOI: 10.1086/677883.
- Hughes JS, MA Weiland, CM Woodley, GR Ploskey, SM Carpenter, MJ Hennen, ES Fisher, GW Batten, TJ Carlson, AW Cushing, Z Deng, DJ Etherington, T Fu, MJ Greiner, M Ingraham, J Kim, X Lix, J Martinez, TD Mitchell, R Rayamah, A Seaburg, JR Skalski, RL Townsend, KA Wagner and SA Zimmerman. 2013. *Survival and passage of yearling and subyearling Chinook salmon and juvenile steelhead at McNary Dam, 2012*. PNNL-22788. Portland, OR: Pacific Northwest National Laboratory. Final report submitted to the U.S. Army Corps of Engineers.
- Hulett PL, CW Wagemann and SA Leider. 1996. *Studies of Hatchery and Wild Steelhead in the Lower Columbia Region, Progress report for fiscal year 1995*. Fish Management Program Report RAD 96-01. Washington Department of Fish and Wildlife.

ICTRT. 2003. *Independent populations of Chinook, steelhead, and sockeye for listed evolutionarily significant units within the Interior Columbia River Domain. Working draft*, Seattle, WA: Interior Columbia Basin Technical Review Team (ICTRT), Northwest Fisheries Science Center.

https://www.nwfsc.noaa.gov/research/divisions/cb/genetics/trt/col/trt_pop_id.cfm.

IDFG. 2016. *Kokanee rebound in Lake Pend Oreille*. Public communication by Idaho Department of Fish and Wildlife. Available at <https://idfg.idaho.gov/region/panhandle/kokanee-rebound-2016>.

IPC IPC. 1991. "Idaho Power Fall chinook interim recovery plan and study. August. IPC, Boise, ID. 28 p. Presented to: Northwest Power Planning Council and National Marine Fisheries Service. ."

ISAB. 2007a. *Climate change impacts on Columbia River Basin fish and wildlife*. ISAB 2007-2. Portland, OR: Independent Scientific Advisory Board (ISAB). Available at

https://www.nwcouncil.org/sites/default/files/isab2007_2.pdf.

ISAB. 2007b. *Latent mortality report: Review of hypotheses and causative factors contributing to latent mortality and their likely relevance to the "Below Bonneville" component of the COMPASS model*. ISAB 2007-1. Portland, OR: Independent Scientific Advisory Board (ISAB). Available at

<https://www.nwcouncil.org/fish-and-wildlife/fw-independent-advisory-committees/independent-scientific-advisory-board>.

ISAB. 2008. *Snake River Spill-Transport Review*. ISAB 2008-5 Independent Scientific Advisory Board (ISAB). Available at https://app.nwcouncil.org/media/31279/isab2008_5.pdf.

ISAB. 2011. *Columbia River food webs: Developing a broader scientific foundation for fish and wildlife restoration*. ISAB 2011-1. Portland, OR: Independent Scientific Advisory Board (ISAB). Available at

<https://www.nwcouncil.org/fish-and-wildlife/fw-independent-advisory-committees/independent-scientific-advisory-board>.

ISAB. 2012. Memorandum to ISAB Administrative Oversight Panel, Bruce Measure (NPCC), Paul Lumley (CRITFC), John Stein (NWFSC). "Follow-up to ISAB reviews of three FPC memos and CSS annual reports regarding latent mortality of in-river migrants due to route of dam passage (Memorandum ISAB 2012-1)." January 3, 2012. Portland, OR: Independent Scientific Advisory Board (ISAB), Chair Rich Alldredge.

Available at https://www.nwcouncil.org/sites/default/files/isab2012_1.pdf.

ISAB. 2015. *Density dependence and its implications for fish management and restoration in the Columbia River Basin*. ISAB 2015-1. Portland, OR: Independent Scientific Advisory Board (ISAB). Available at

https://www.nwcouncil.org/sites/default/files/isab2015-1_0.pdf.

ISAB. 2019. *A review of predation impacts and management effectiveness for the Columbia River Basin*.

ISAB 2019-1. Portland, OR: Independent Scientific Advisory Board (ISAB). Available at

<https://www.nwcouncil.org/fish-and-wildlife/fw-independent-advisory-committees/independent-scientific-advisory-board>.

Jacobson K, B Peterson, M Trudel, J Ferguson, C Morgan, D Welch, A Baptista, B Beckman, R Brodeur, E Casillas, R Emmett, J Miller, D Teel, T Wainwright, L Weitkamp, J Zamon and K Fresh. 2012. *The marine ecology of juvenile Columbia River Basin salmonids: A synthesis of research 1998-2011*, Portland, OR: Prepared by NMFS, NOAA, Fisheries and Oceans Canada, Kintama Research Services, and Oregon State University for the Northwest Power and Conservation Council.

Jensen JOT, J Schnute and DF Alderdice. 1986. "Assessing Juvenile Salmonid Response to Gas Supersaturation Using a General Multivariate Dose-Response Model." *Canadian Journal of Fisheries and Aquatic Sciences* 43(9):1694-1709. DOI: 10.1139/f86-213.

Jepson MA, ML Keefer, CC Caudill, TS Clabough, CS Erdman, T Blubaugh and CS Sharpe. 2015. *Migratory behavior, run timing, and distribution of radiotagged adult winter Steelhead, summer Steelhead, spring Chinook salmon, and Coho salmon in the Willamette River: 2011-2014*. Portland, OR: U.S. Army, Corps of Engineers, Technical Report 2015-1.

[http://pweb.crohms.org/tmt/documents/FPOM/2010/Willamette_Coordination/Willamette%20RME/Jepson%20et%20al%202015-](http://pweb.crohms.org/tmt/documents/FPOM/2010/Willamette_Coordination/Willamette%20RME/Jepson%20et%20al%202015-1)

1_2014%20WMR%20mainstem%20CK%20SH%20Coho%20RT%2017Apr15.pdf. Available at <https://www.uidaho.edu/-/media/UIDaho-Responsive/Files/cnr/FERL/technical-reports/2015/2015-01-WMR.pdf?la=en&hash=E854EB31537BED2792C4D6AE4793E106B516E375>.

Johnson GE, KL Fresh and NK Sather, Eds. 2018. *Columbia Estuary Ecosystem Restoration Program: 2018 Synthesis Memorandum*. Richland, WA: Pacific Northwest National Laboratory. PNNL-27617, Final report submitted by Pacific Northwest National Laboratory to U.S. Army Corps of Engineers, Portland District, Portland, OR. Available at

<https://www.cbfish.org/FileResource.mvc/DownloadPdfFileResource/ac2b21e9-903a-4428-bbc9-13db44abf025>.

Johnson GE, GR Ploskey, NK Sather and DJ Teel. 2015. "Residence times of juvenile salmon and steelhead in off-channel tidal freshwater habitats, Columbia River, USA." *Canadian Journal of Fisheries and Aquatic Sciences* 72(5):684-696. DOI: 10.1139/cjfas-2014-0085.

Johnson MA, TA Friesen, DJ Teel and DMV Doornik. 2013. *Genetic stock identification and relative natural production of Willamette River steelhead*. U.S. Army Corps of Engineers, Portland District, Task Order No. W9127N-10-2-0008-0015. Available at

https://odfw.forestry.oregonstate.edu/willamettesalmonidrm/sites/default/files/hatchery-research/odfw_willamette_steelhead_genetics_synthesis.pdf.

Johnson OW, W.S. Grant, R.G. Kope, K. Neely, F.W. Waknitz and RS Waples. 1997. "Status review of chum salmon from Washington, Oregon, and California. NOAA Tec. Memo. NMFS-NWFSC-32. 298 pgs."

Johnson SL, JD Rodgers, MF Solazzi and TE Nickelson. 2005. "Effects of an increase in large wood on abundance and survival of juvenile salmonids (*Oncorhynchus spp.*) in an Oregon coastal stream." *Canadian Journal of Fisheries and Aquatic Science* 62(2):412-424. Hardcopy, TH's Library: CJFAS 62:412. DOI: 10.1139/f04-222.

Joint Columbia River Management Staff. 2010. *2010 Joint Staff Report Concerning Stock Status and Fisheries for Sturgeon and Smelt*. Clackamas, OR: Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW). Available at

<https://wdfw.wa.gov/publications/00886>.

Jones KK, K Anlauf-Dunn, PS Jacobsen, M Strickland, L Tennant and SE Tippery. 2014. "Effectiveness of instream wood treatments to restore stream complexity and winter rearing habitat for juvenile coho salmon." *Transactions of the American Fisheries Society* 143(2):334-345. DOI: 10.1080/00028487.2013.852623.

Jones R. 2015. *2015 5-year review - Listing status under the Endangered Species Act for hatchery programs associated with 28 salmon evolutionarily significant units and steelhead distinct population segments*, Portland, OR: Memorandum for Chris Yates from Rob Jones, National Marine Fisheries Service.

Keefer M, C Caudill, T Clabough, K Collis, A Evans, C Fitzgerald, M Jepson, G Naughton, R O'Connor and Q Payton. 2016. *Final technical report: Adult steelhead passage behaviors and survival in the Federal*

Columbia River Power System. Walla Walla, WA: U.S. Army Corps of Engineers, Walla Walla District, IDIQ Contract No. W912EF-14-D-0004. Available at https://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/middle_columbia/FC%20Mid-C%20Initiative/Tributary%20Overshoot/adult_steelhead_summary_final_technical_report.pdf.

Keefer ML and CC Caudill. 2014. "Homing and Straying by Anadromous Salmonids: A Review of Mechanisms and Rates." *Reviews in Fish Biology and Fisheries* 24(1):333-368. DOI: 10.1007/s11160-013-9334-6.

Keefer ML and CC Caudill. 2017. *Assembly and analysis of radiotelemetry and temperature logger data from adult Chinook salmon and steelhead migrating through the Columbia River basin*. Prepared for Tetra Tech and the Environmental Protection Agency. Technical Report 2017-1. Available at <https://www.uidaho.edu/-/media/UIDaho-Responsive/Files/cnr/FERL/technical-reports/2017/2017-1-RDST-EPA.pdf?la=en&hash=FEF07B1A63853179FBDEA9288049CECDCBDCEF51>.

Keefer ML, CA Peery, TC Bjornn, MA Jepson and LC Stuehrenberg. 2004. "Hydrosystem, dam, and reservoir passage rates of adult Chinook salmon and steelhead in the Columbia and Snake Rivers." *Transactions of the American Fisheries Society* 133(6):1413-1439. Hardcopy: TH's Library, TAFS 133:1413. DOI: 10.1577/T03-223.1.

Keefer ML, CA Peery, TC Bjornn, MA Jepson, KR Tolotti, RR Ringe and LC Stuehrenberg. 2007. *Adult salmon and steelhead passage through fishways and transition pools at the Dalles Dam, 1997-2001*. Technical Report 2007-2. A report for Project MPE-P-95-1. Prepared for U.S. Army Corps of Engineers, Portland, OR and Walla Walla, WA; Bonneville Power Administration, Portland, OR. Available at <https://usace.contentdm.oclc.org/digital/collection/p16021coll3/id/457/>.

Keefer ML, CA Peery, WR Daigle, MA Jepson, SR Lee, CT Boggs, KR Tolotti and BJ Burke. 2005. "Escapement, harvest, and unknown loss of radio-tagged adult salmonids in the Columbia River - Snake River hydrosystem." *Canadian Journal of Fisheries and Aquatic Sciences* 62(4):930-949. DOI: 10.1139/f04-246.

Kennedy BP, JD Blum, CL Folt and KH Nislow. 2000. "Using natural strontium isotopic signatures as fish markers: methodology and application." *Canadian Journal of Fisheries and Aquatic Sciences* 57(11):2280-2292. DOI: 10.1139/f00-206.

Khan F, GE Johnson and MA Weiland. 2009. *Hydroacoustic Evaluation of Overwintering Summer Steelhead Fallback and Kelt Passage at The Dalles Dam 2008-2009*. PNNL-18590. Richland, WA: Pacific Northwest National Laboratory. Final report to the U.S. Army Corps of Engineers, Portland District, Portland, OR.

Khan F, IM Royer, GE Johnson and SC Tackley. 2013. "Sluiceway Operations for Adult Steelhead Downstream Passage at The Dalles Dam, Columbia River, USA." *North American Journal of Fisheries Management* 33(5):1013-1023. DOI: 10.1080/02755947.2013.793629.

Kidd SA, AC Hanson, MD Schwartz, RN Fuller, R McNatt, K Poppe, TD Peterson, JA Needoba, J Cordell, M Ramirez, AB Borde, SA Zimmerman, PM Chittaro, D Kuligowski, GM Ylitalo, D Lomax, S Hinton, VI Cullinan, LL Johnson and HL Corbett. 2018. *Lower Columbia River Ecosystem Monitoring Program, Annual Report for Year 13 (October 1, 2016 to September 30, 2017)*. Prepared for Bonneville Power Administration, Portland, Oregon, 5/1/2018.

- Kilduff DP, E Di Lorenzo, LW Botsford and SLH Teo. 2015. "Changing central Pacific El Niños reduce stability of North American salmon survival rates." *Proceedings of the National Academy of Sciences* 112(35):10962–10966. DOI: 10.1073/pnas.1503190112.
- Kline PA, TA Flagg, CC Kozfkay, DJ Baker, DJ Maynard and WC McAuley. 2019. "Snake River Sockeye Salmon—a perspective on twenty-five years of effort to recover a population in central, Idaho, USA." In *From catastrophe to recovery: stories of fishery management success*, pp. 101–103. Bethesda, Maryland: American Fisheries Society.
- Kline T and B Fuji. 1993. Memorandum to D. Moscovitz et al. "Weak stocks and water supply conflicts." September 17, 2013. Salem, OR: Oregon Water Resources Department (OWRD).
- Kock TJ, JL Congleton and PJ Anders. 2006. "Effects of sediment cover on survival and development of white sturgeon embryos." *North American Journal of Fisheries Management* 26(1):134–141. DOI: 10.1577/M05-073.1
- Kootenai Tribe of Idaho and WP Montana Fish. 2004. *Kootenai Subbasin Plan. Part I: Kootenai River Subbasin Assessment*. Portland, OR: Northwest Power and Conservation Council. Available at <https://www.nwcouncil.org/subbasin-plans/kootenai-subbasin-plan>.
- Kostow KE, AR Marshall and SR Phelps. 2003. "Naturally spawning hatchery steelhead contribute to smolt production but experience low reproductive success." *Transactions of the American Fisheries Society* 132(4):780–791. Hardcopy in TH's Library: TAFS 132:780. DOI: 10.1577/T02-051.
- Kostow KE and S Zhou. 2006. "The effect of an introduced summer steelhead hatchery stock on the productivity of a wild winter steelhead population." *Transactions of the American Fisheries Society* 135(3):825–841. Hardcopy in TH's Library: TAFS 135:825. DOI: 10.1577/T04-204.1.
- KTOI. 2009. *Kootenai River Habitat Restoration Project Master Plan: A Conceptual Feasibility Analysis and Design Framework*. Bonners Ferry, ID: Kootenai Tribe of Idaho (KTOI).
- Kukulka T and DA Jay. 2003. "Impacts of Columbia River discharge on salmonid habitat: 2. Changes in shallow-water habitat." *Journal of Geophysical Research: Oceans* 108(C9):3294. DOI: 10.1029/2003JC001829.
- Lackey RT. 2003. "Pacific Northwest Salmon: Forecasting Their Status in 2100." *Reviews in Fisheries Science* 11(1):35–88. DOI: 10.1080/16226510390856529.
- LCREP. 2007. *Lower Columbia River Estuary Ecosystem Monitoring: Water Quality and Salmon Sampling Report*. Portland, OR: Lower Columbia River Estuary Partnership (LCREP). Available at <http://www.lcrep.org/sites/default/files/pdfs/WaterSalmonReport.pdf>.
- LCREP. 2011. *Lower Columbia River Estuary Plan: Comprehensive Conservation and Management Plan--2011 Update*. Portland, OR: Lower Columbia River Estuary Partnership (LCREP). Available at <http://www.estuarypartnership.org/sites/default/files/CCMP%20Action%20Update%20Final%202012.pdf>.
- LeCaire R. 2000. *Chief Joseph Kokanee Enhancement Project. 1999 Annual Report*. Portland, OR: Bonneville Power Administration. Project Number 9501100.
- Lee DC, JR Sedell, BF Rieman, RF Thurow and JE Williams. 1997. "Broadscale assessment of aquatic species and habitats." In *An assessment of ecosystem components in the interior Columbia Basin and portions of the Klamath and Great Basins: Volume 3*, pp. 1058–1496. eds: TM Quigley and SJ Arbelbide. Ch. 4. Portland, OR: Gen. Tech. Rep. PNW-GTR-405. U.S. Forest Service, Pacific Northwest Research

Station. 3. See BA-11119, BA-11120, BA-11121, and BA-11122 for full report. DOI: 10.2737/PNW-GTR-405.

Leider SA, MW Chilcote and JJ Loch. 1986. "Comparative Life-History Characteristics of Hatchery and Wild Steelhead Trout (*Salmo-Gairdneri*) of Summer and Winter Races in the Kalama River, Washington." *Canadian Journal of Fisheries and Aquatic Sciences* 43(7):1398-1409. DOI: 10.1139/f86-173.

Lemly AD. 2002. *Selenium Assessment in Aquatic Systems. A Guide for Hazard Evaluation and Water Quality Criteria*, New York, NY: Springer-Verlag.

Lemmen DS, FJ Warren, TS James and CSL Mercer Clarke, Eds. 2016. *Canada's marine coasts in a changing climate*. Ottawa, ON: Government of Canada. ISBN 978-0-660-05051-5.

Levin PS, S Achord, BE Feist and RW Zabel. 2002. "Non-indigenous brook trout and the demise of Pacific salmon: a forgotten threat?" *Proceedings of the Royal Society of London. Series B: Biological Sciences* 269(1501):1663-1670. TH's library Call No. L285 [Discarded]. DOI: 10.1098/rspb.2002.2063.

LGL and Douglas PUD. 2006. *Wells Bull Trout Monitoring and Management Plan. 2005 Annual Report*. LGL Limited Environmental Research Associates and Douglas County Public Utility District (LGL and DPUD). Wells Hydroelectric Project FERC No. 2149. Prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, WA.

LGL and Douglas PUD. 2008. *Wells Bull Trout Monitoring and Management Plan. 2005-2008 Final Report*. LGL Limited Environmental Research Associates and Douglas County Public Utility District (LGL and DPUD). Wells Hydroelectric Project FERC No. 2149. Prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, WA. Available at http://relicensing.douglaspud.org/background/annual_reports/reports/2005_2008_Final_Report_Bull_T_rout.pdf.

Lomeli MJM, SD Groth, MTO Blume, B Herrmann, WW Wakefield and E Anderson. 2018. "Effects on the bycatch of eulachon and juvenile groundfish by altering the level of artificial illumination along an ocean shrimp trawl fishing line." *ICES Journal of Marine Science* 75(6):2224-2234. DOI: 10.1093/icesjms/fsy105.

Lundin JI, JA Spromberg, JC Jorgensen, JM Myers, PM Chittaro, RW Zabel, LL Johnson, RM Neely and NL Scholz. 2019. "Legacy habitat contamination as a limiting factor for Chinook salmon recovery in the Willamette Basin, Oregon, USA." *PLOS ONE* 14(3):e0214399. DOI: 10.1371/journal.pone.0214399.

Lynch M and M O'Hely. 2001. "Captive breeding and the genetic fitness of natural populations." *Conservation Genetics* 2:363-378. DOI: 10.1023/A:1012550620717.

Ma Q, R Li, J Feng, J Lu and Q Zhou. 2018. "Cumulative Effects of Cascade Hydropower Stations on Total Dissolved Gas Supersaturation." *Environmental Science and Pollution Research* 25(14):13536-13547. DOI: 10.1007/s11356-018-1496-2.

Maier G. 2014. "Integrated recovery program - Habitat Report. Draft report of the Upper Columbia Salmon Recovery Board. Wenatchee, WA."

Maier G. 2017. *Upper Columbia integrated recovery hatchery background summary*. Wenatchee, WA: Upper Columbia Salmon Recovery Board. Available at <http://www.ucsr.org/mdocuments-library/reports/>.

Maier GO and CA Simenstad. 2009. "The role of marsh-derived macrodetritus to the food webs of juvenile Chinook salmon in a large altered estuary." *Estuaries and Coasts* 32(5):984-998. DOI: 10.1007/s12237-009-9197-1.

Mantua NJ. 2009. "Patterns of change in climate and Pacific salmon production." In *Pacific salmon: Ecology and management of Western Alaska's population*, pp. 1143-1157. American Fisheries Society Symposium 70 ed. eds: CC Krueger and CE Zimmerman. Ch. Section V. Bethesda, MA: American Fisheries Society.

Marcoe K and S Pilson. 2017. "Habitat change in the lower Columbia River estuary, 1870–2009." *Journal of Coastal Conservation* 21(4):505-525. DOI: 10.1007/s11852-017-0523-7.

Marotz B, B Hansen and S Tralles. 1988. *Instream flows needed for successful migration, spawning, and rearing of rainbow and westslope cutthroat trout in selected tributaries of the Kootenai River. Final report*. Kalispell, MT: Montana Department of Fish, Wildlife, and Parks.

Marotz BL, SR Dalbey, C Muhlfeld, S Snelson, G Hoffman, J DosSantos and S Ireland. 1998. *Fisheries mitigation and implementation plan for losses attributable to the construction and operation of Libby Dam*. Kalispell, MT: Montana Fish, Wildlife and Parks; Kootenai Tribes, Pablo, Montana; Kootenai Tribe of Idaho.

Marotz BL, D Gustafson, CL Althen and W Lonon. 1996. *Model development to establish integrated operational rule curves for Hungry Horse and Libby Reservoirs - Montana*. Montana Department of Fish, Wildlife, and Parks. Prepared for Bonneville Power Administration.

Marotz BL, D Gustafson, CL Althen and W Lonon. 1999. *Integrated operational rule curves for Montana reservoirs and application for other Columbia River storage projects* Alaska Sea Grant College Program. AK-SG-99-01. 329-352 ISBN 978-1-56612-061-6.

McCann J. 2018. Letter to RJ Graves. "Multi-year Reach Survival and Fish Travel Time Data Tables." July 10, 2018.

McCarter PB and DE Hay. 1999. *Distribution of spawning eulachon stocks in the central coast of British Columbia as indicated by larval surveys*. Canadian Stock Assessment Secretariat Research Document 99/177. Ottawa, Ontario, Canada: Department of Fisheries and Oceans.

McElhany P, M Chilcote, J Myers and R Beamesderfer. 2007. *Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins, Review Draft*. Seattle, WA: NOAA Fisheries, Northwest Fisheries Science Center.

McElhany P, MH Ruckelshaus, MJ Ford, TC Wainwright and EP Bjorkstedt. 2000. *Viable salmonid populations and the recovery of evolutionary significant units*. NOAA Technical Memorandum NMFS-NWFSC-42. Seattle, WA: U.S. Department of Commerce, NOAA Fisheries. Available at https://www.nwfsc.noaa.gov/assets/25/6190_06162004_143739_tm42.pdf.

McGrath KE, EM Dawley and DR Geist. 2006. *Total dissolved gas effects on fishes of the lower Columbia River: Final report*. Portland, OR: PNNL-15525. Prepared by Pacific Northwest National Laboratory under Contract DE-AC05-76RL01830 for the U.S. Army Corps of Engineers. Available at https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-15525.pdf.

McHugh JL. 1939. "The eulachon. Progress report of the Pacific Biological Station, Nanaimo, B.C., and Pacific Fisheries Experimental Station, Prince Rupert, BC." 40:17-22.

McIntosh BA, JR Sedell, JE Smith, RC Wissmar, SE Clarke, GH Reeves and LA Brown. 1994. *Management history of eastside ecosystems: changes in fish habitat over 50 years, 1935-1992*. Portland, OR: General Technical Report PNW-GTR-321. U.S. Forest Service, Pacific Northwest Research Station. TH's Library Call No. M300 [Discarded]. DOI: 10.2737/PNW-GTR-321. Available at <https://www.fs.usda.gov/treearch/pubs/6232>.

McMichael GA, RA Harnish, AC Hanson and CR Vernon. 2014. *Ecological interactions between hatchery summer steelhead and wild *Oncorhynchus mykiss* in the Willamette Basin: Final report*, Portland, OR: Prepared by Pacific Northwest National Laboratory, PNNL-22929, for the U.S. Army Corps of Engineers under Contract W66QkZ30077680.

McMichael GA, RA Harnish, JR Skalski, KA Deters, KD Ham, RL Townsend, PS Titzler, MS Hughes, J Kim and DM Trott. 2011. *Migratory behavior and survival of juvenile salmonids in the Lower Columbia River, estuary, and plume in 2010*. Richland, WA: PNNL-20443, Pacific Northwest National Laboratory. Available at https://www.pnnl.gov/main/publications/external/technical_reports/pnnl-20443.pdf.

McPhail JD and CC Lindsey. 1970. *Freshwater Fishes of Northwestern Canada and Alaska (Bulletin - Fisheries Research Board of Canada; 173)*, Ottawa, Canada: Fisheries Research Board of Canada.

Mesa MG. 1994. "Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile Chinook salmon. *Transactions of the American Fisheries Society* 123:786-793."

Mesa MG and TM Olson. 1993. "Prolonged swimming performance of northern squawfish. *Transactions of the American Fisheries Society* 122:1104-1110."

Meyer KA, E Garton and DJ Schill. 2014. "Bull Trout Trends in Abundance and Probabilities of Persistence in Idaho." *North American Journal of Fisheries Management* 34(1):202-214 DOI: <https://doi.org/10.1080/02755947.2013.869280>

Minshall GW, B Shafii, WJ Price, C Holderman, PJ Anders, G Lester and P Barrett. 2014. "Effects of nutrient replacement on benthic macroinvertebrates in an ultraoligotrophic reach of the Kootenai River, 2003–2010." *Freshwater Science* 33:1009-1023.

Mote P, AK Snover, S Capalbo, SD Eigenbrode, P Glick, J Littell, R Raymondi and S Reeder. 2014. "Ch. 21: Northwest." In *Climate change impacts in the United States: The third national climate assessment*, pp. 487-513. eds: JM Melillo, TTC Richmond and GW Yohe. Ch. 21. Washington, D.C.: U.S. Global Change Research Program. Full report: EC-14546. DOI: 10.7930/J04Q7RWX.

Muhlfeld CC, JJ Giersch, FR Hauer, GT Pederson, G Luikart, DP Peterson, CC Downs and DB Fagre. 2011. "Climate change links fate of glaciers and an endemic alpine invertebrate." *Climatic Change* 106(2):337-345. DOI: 10.1007/s10584-011-0057-1.

Muhlfeld CC, S Glutting, R Hunt, D Daniels and B Marotz. 2003. "Winter Diel Habitat Use and Movement by Subadult Bull Trout in the Upper Flathead River, Montana." *North American Journal of Fisheries Management* 23(1):163-171. DOI: 10.1577/1548-8675(2003)023<0163:WDHUAM>2.0.CO;2.

Muir WD, DM Marsh, BP Sandford, SG Smith and JG Williams. 2006. "Post-Hydropower System Delayed Mortality of Transported Snake River Stream-Type Chinook Salmon: Unraveling the Mystery." *Transactions of the American Fisheries Society* 135(6):1523-1534. DOI: 10.1577/T06-049.1.

Muir WD, SG Smith, JG Williams and BP Sandford. 2001. "Survival of Juvenile Salmonids Passing through Bypass Systems, Turbines, and Spillways with and without Flow Deflectors at Snake River Dams." *North American Journal of Fisheries Management* 21(1):135-146. DOI: 10.1577/1548-8675(2001)021<0135:SOJSPT>2.0.CO;2.

Mullan JW, KR Williams, G Rhodus, TW Hillman and JD McIntyre. 1992. "Production and habitat of salmonids in the mid-Columbia river tributary streams. USFWS. Monograph I."

Myers J, C Busack, D Rawding, A Marshall, DJ Teel, DM Van Doornik and MT Maher. 2006. *Historical population structure of Pacific salmonids in the Willamette and lower Columbia River basins*. NMFS-NWFSC-73. Seattle, WA: NOAA Fisheries.

- Naiman RJ, RE Bilby and PA Bisson. 2000. "Riparian ecology and management in the Pacific coastal rain forest." *BioScience* 50(11):996-1011. DOI: 10.1641/0006-3568(2000)050[0996:REAMIT]2.0.CO;2.
- Naiman RJ, RE Bilby, DE Schindler and JM Helfield. 2002. "Pacific salmon, nutrients, and dynamics of freshwater and Riparian Ecosystems." *Ecosystems* 5(4):399-417. DOI: 10.1007/s10021-001-0083-3.
- National Research Council. 1996. *Upstream: Salmon and Society in Pacific Northwest*, Washington, D.C.: National Academy Press.
- National Research Council. 2004. *Managing the Columbia River: Instream Flows, Water Withdrawals, and Salmon Survival*, Washington, DC: National Academies Press.
- Naughton GP, DH Bennett and KB Newman. 2004. "Predation on juvenile salmonids by small mouth bass in the lower granite reservoir system, Snake River." *North American Journal of Fisheries Management* 24(2):534-544. Hardcopy, TH's Library: NAJFM 24:534. DOI: 10.1577/M02-177.1.
- NMFS. 2000. *White paper: predation on salmonids relative to the Federal Columbia River Power System*. Seattle, WA: National Marine Fisheries Service, Northwest Fisheries Science Center.
- NMFS. 2005. *Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs*. *Federal Register* 70:123 (28 June 2005):37160-37216.
- NMFS. 2007. *Endangered Species Act – Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on the Habitat Restoration Program submitted by the State of Washington, Governor’s Salmon Recovery Office, or ESA Section 4(d) Limit 8*. Portland, OR: National Marine Fisheries Service.
- NMFS. 2008a. *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Consultation on the "Willamette River Basin Flood Control Project"*. Portland, OR: NOAA Fisheries. Prepared for the U.S. Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation. NOAA Fisheries Log No. FINWRI2000/02117. Available at https://www.nwcouncil.org/sites/default/files/willamette_biop_final_part1_july_2008.pdf, <http://www.sswc.org/wp-content/uploads/2008/12/Willamette-BiOP-Chapter-4.pdf>, and https://www.nwcouncil.org/sites/default/files/willamette_biop_final_part3_july_2008_1.pdf.
- NMFS. 2008b. *Endangered Species Act Section 7(a)(2) Consultation, Final Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation: 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)(1)(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)]*, Portland, OR: NOAA Fisheries, Northwest Region. Prepared for the U.S. Army Corps of Engineers, Bonneville Power Administration, U.S. Bureau of Reclamation, and NOAA's NMFS.
- NMFS. 2008c. *Recovery plan for southern resident killer whales (Orcinus orca)*. Seattle, WA: Northwest Regional Office, National Marine Fisheries Service. Available at <https://www.fisheries.noaa.gov/resource/document/recovery-plan-southern-resident-killer-whales-orcinus-orca>.
- NMFS. 2008d. *Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and Other Tributary Actions*. Portland, OR: NOAA Fisheries. Available at <https://www.westcoast.fisheries.noaa.gov/publications/hydropower/fcrps/final-sca.pdf>.

- NMFS. 2009. *Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan*.
- NMFS. 2011a. *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead*. Portland, OR: NOAA Fisheries. Prepared by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc., subcontractor. Available at <https://repository.library.noaa.gov/view/noaa/17401>.
- NMFS. 2011b. *Evaluation of and Recommended Determination on a Resource Management Plan (RMP), Pursuant to the Salmon and Steelhead 4(d) rule Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component*. Portland, OR: NOAA Fisheries.
- NMFS. 2013. *Endangered Species Act Section 7 Formal Programmatic Opinion, Letter of Concurrence and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Conservation Recommendations*. Portland, OR: NOAA Fisheries. Habitat Improvement Program III funded by the Bonneville Power Administration in the Columbia River Basin in Oregon, Washington, and Idaho. NMFS Consultation No. 2013/9724. Available at https://www.nww.usace.army.mil/Portals/28/docs/regulatory/ESA%20Programmatic/HIPIII_NMFS_BiOp_03.22.2013.pdf.
- NMFS. 2014a. *Module for the Ocean Environment*. Portland, OR: NOAA Fisheries. Prepared by the Northwest Fisheries Science Center for NOAA Fisheries, Northwest Regional Office. Available at https://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/Final%20Snake%20Recovery%20Plan%20Docs/ocean_module_nov_2017.pdf.
- NMFS. 2014b. *Supplemental Recovery Plan Module for Snake River Salmon and Steelhead: Mainstem Columbia River Hydropower Projects*. Portland, OR: NOAA Fisheries, West Coast Region. Available at https://archive.fisheries.noaa.gov/wcr/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/hydro_supplemental_recovery_plan_module_063014.pdf.
- NMFS. 2015. *ESA Recovery Plan for Snake River Sockeye Salmon (Oncorhynchus nerka)*. NOAA Fisheries, West Coast Region. Available at https://archive.fisheries.noaa.gov/wcr/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/snake_river_sockeye_recovery_plan_june_2015.pdf.
- NMFS. 2016a. *5-Year Review: Summary & evaluation of Snake River sockeye, Snake River spring-summer Chinook, Snake River fall-run Chinook, Snake River basin steelhead*. Portland, OR: U.S. Department of Commerce, NOAA Fisheries, National Marine Fisheries Service. Available at https://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016_status_review.html.
- NMFS. 2016b. *5-Year review: Summary & evaluation of Upper Columbia River steelhead, Upper Columbia River spring-run Chinook salmon*. Portland, OR: U.S. Department of Commerce, NOAA Fisheries, National Marine Fisheries Service. Available at https://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016_status_review.html.
- NMFS. 2016c. *2015 Adult Sockeye Salmon Passage Report*. Portland, OR: NOAA Fisheries in collaboration with the US Army Corps of Engineers and Idaho Department of Fish and Game. Available at https://archive.fisheries.noaa.gov/wcr/publications/hydropower/fcrps/2015_adult_sockeye_salmon_passage_report.pdf.
- NMFS. 2016d. *2016 5-Year Review: Summary & Evaluation of Lower Columbia River Chinook Salmon Columbia River Chum Salmon Lower Columbia River Coho Salmon Lower Columbia River Steelhead*.

Portland, OR: NOAA Fisheries, West Coast Region. Available at <https://repository.library.noaa.gov/view/noaa/17021>.

NMFS. 2016e. *2016 5-Year Review: Summary & Evaluation of Upper Willamette River Steelhead Upper Willamette River Chinook*. Portland, OR: National Marine Fisheries Service, West Coast Region. Available at https://archive.fisheries.noaa.gov/wcr/publications/status_reviews/salmon_steelhead/2016/2016_upper-willamette.pdf.

NMFS. 2016f. *Endangered Species Act (ESA) section 7(a)(2) biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat (EFH) consultation: Six lower Snake River spring/summer Chinook salmon hatchery programs*. Portland, OR: NOAA Fisheries, West Coast Region, Consultation No. WCR-2013-21. Available at https://www.fws.gov/snakecomplan/Reports/ESA%20Compliance/Biological%20Opinions/NMFS_Final%20NEOR-SEWA%20Chinook%20BO_06-24-2016.pdf.

NMFS. 2017a. *2017 Supplemental Recovery Plan Module for Snake River Salmon and Steelhead: Mainstem Columbia River Hydropower Projects*, Portland, OR: NOAA Fisheries, West Coast Region. Appendix Section in 3 Snake River Recovery Plans: https://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/snake_river/current_snake_river_recovery_plan_documents.html.

NMFS. 2017b. *Endangered Species Act (ESA) section 7(a)(2) biological opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) consultation: Nine Snake River steelhead hatchery programs and one kelt reconditioning program in Idaho*. Portland, OR: NOAA Fisheries, West Coast Region, Consultation No. WCR-2017-7286. Available at https://www.fws.gov/snakecomplan/Reports/ESA%20Compliance/Biological%20Opinions/NMFS_Final%20Idaho%20steelhead%20BO_12-12-2017.pdf.

NMFS. 2017c. *ESA Recovery Plan for Snake River Fall Chinook Salmon (*Oncorhynchus tshawytscha*)*, Portland, OR: NOAA Fisheries, West Coast Region.

NMFS. 2017d. *ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*) & Snake River Basin Steelhead (*Oncorhynchus mykiss*)*. Portland, OR: NOAA Fisheries, West Coast Region. Available at https://archive.fisheries.noaa.gov/wcr/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/Final%20Snake%20Recovery%20Plan%20Docs/final_snake_river_spring-summer_chinook_salmon_and_snake_river_basin_steelhead_recovery_plan.pdf.

NMFS. 2017e. *Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*)*. Portland, OR: NOAA Fisheries, West Coast Region. Available at <https://www.fisheries.noaa.gov/resource/document/recovery-plan-southern-distinct-population-segment-eulachon-thaleichthys>.

NMFS. 2018a. *Draft Environmental Impact Statement (DEIS) to Analyze Impacts of NOAA's National Marine Fisheries Service Proposed Approval of Hatchery and Genetic Management Plans for spring Chinook salmon, steelhead, and rainbow trout in the Upper Willamette River Basin Pursuant to Section 4(d) of the Endangered Species Act*. Portland, Oregon: National Marine Fisheries Service, West Coast Region. Available at https://archive.fisheries.noaa.gov/wcr/publications/nepa/hatchery/upperwillamettehatcheries_deis_march2018.pdf.

NMFS. 2018b. *Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response. Consultation on Effects of the 2018-2027 U.S. v. Oregon Management Agreement*. Lacey, WA: NOAA Fisheries, West Coast Region, Consultation No. WCR-2017-7164. Available at

https://www.westcoast.fisheries.noaa.gov/publications/fishery_management/salmon_steelhead/s7-uvvoregon_2018-2027_mgmagmnt_final_signed.pdf.

NMFS. 2019. *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*. Portland, OR: NOAA Fisheries, West Coast Region. NMFS Consultation No. WCRO-2018-00152. Available at

https://www.westcoast.fisheries.noaa.gov/publications/hydropower/fcrps/master_2019_crs_biological_opinion_1.pdf.

NMFS and WDFW. 2018. *Southern Resident Killer Whale Priority Chinook Stocks Report*. NOAA Fisheries West Coast Region and Washington Department of Fish and Wildlife (WDFW). Available at https://archive.fisheries.noaa.gov/wcr/publications/protected_species/marine_mammals/killer_whales/recovery/srkw_priority_chinook_stocks_conceptual_model_report_list_22june2018.pdf.

Normandeau. 2014. *Direct Survival/Condition of Subadult and Adult Rainbow Trout Passing Through a Spillbay and Turbine at Albeni Falls Dam, Pend Oreille River, Idaho*. Seattle, WA: Normandeau Associates, Inc. (Normandeau). Prepared for U.S. Army Corps of Engineers, Seattle District.

Northwest Power and Conservation Council. 2001. "Dams and Hydropower." Portland, OR. Personal Communication (E-mail).

NPCC. 1992. *Columbia River Basin Fish and Wildlife Program — Strategy for Salmon*. Portland, OR: Northwest Power and Conservation Council (NPCC). Council Document Number 92-21. November 19, 1992. Available at <https://www.nwcouncil.org/fish-and-wildlife/previous-programs/columbia-river-basin-fish-and-wildlife-programstrategy-for-salmon>.

NPCC. 2004a. *Draft Willamette Subbasin Plan*. Northwest Power and Conservation Council (NPCC). Available at https://www.nwcouncil.org/sites/default/files/EntirePlan_15.pdf.

NPCC. 2004b. *Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan*. Prepared for the Northwest Power and Conservation Council (NPCC).

NPCC. 2013. *Columbia Basin White Sturgeon Planning Framework*. Prepared by CRITFC, WDFW and ODFW for the Northwest Power and Conservation Council. R. Beamesderfer and P. Anders, eds. Available at

<https://www.nwcouncil.org/sites/default/files/ColumbiaBasinWhiteSturgeonPlanningFramework2013Dec.pdf>.

NRCS. 2006. *Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin*. Available at

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_050898.pdf.

NWFSC (Northwest Fisheries Science Center). 2016. *Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest*. Seattle, WA: Northwest Fisheries Science Center (NWFSC). Available at

https://www.nwfsc.noaa.gov/assets/11/8623_03072016_124156_Ford-NWSalmonBioStatusReviewUpdate-Dec%2021-2015%20v2.pdf.

NWFSC (Northwest Fisheries Science Center). 2015. *Status review update for pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest*. National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center. Available at https://www.nwfsc.noaa.gov/assets/11/8623_03072016_124156_Ford-NWSalmonBioStatusReviewUpdate-Dec%2021-2015%20v2.pdf.

NWFSC NFSC. 2015. "Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. 356 pages."

ODEQ. 2013. "Water Quality Assessment Database, Clean Water Act Water Quality Assessment, Oregon's 2010 Integrated Report." Portland, OR: Oregon Department of Environmental Quality (ODEQ). Available at <http://www.deq.state.or.us/wq/assessment/rpt2010/search.asp#db>. Database download for the Walla Walla subbasin. Data downloaded on September 23, 2013.

ODFW and NMFS. 2011. *Upper Willamette River Conservation & Recovery Plan for Chinook Salmon and Steelhead, Final*. Oregon Department of Fish and Wildlife (ODFW) and NOAA Fisheries. Available at https://dfw.state.or.us/fish/CRP/upper_willamette_river_plan.asp.

OFC. 1953. *Columbia River Progress Report 1953*. Portland, OR: Oregon Fish Commission (OFC).

Pacific States Marine Fisheries Commission. 2014. *Pacific States Marine Fisheries Commission 2014 Annual Report*. Portland, OR: Pacific States Marine Fisheries Commission. Available at https://www.psmfc.org/wp-content/uploads/2015/08/PSMFC_2014_Final.pdf.

Paragamian VL. 2012. "Kootenai River White Sturgeon: Synthesis of Two Decades of Research." *Endangered Species Research* 17(2):157-167. DOI: 10.3354/esr00407.

Paragamian VL, RCP Beamesderfer and SC Ireland. 2005. "Status, Population Dynamics, and Future Prospects of the Endangered Kootenai River White Sturgeon Population with and without Hatchery Intervention." *Transactions of the American Fisheries Society* 134(2):518-532. DOI: 10.1577/T03-011.1.

Paragamian VL, C Gidley and JP Walters. 2010. *Kootenai River Fisheries Investigations: Salmonid Studies, Bull Trout Studies Summary Report, April 1, 1998 to April 30, 2010*. IDFG Report Number 10-07. Boise, ID: Idaho Department of Fish and Game. Available at <https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/Res10-07Paragamian1998-2009%20Bull%20Trout%20Studies%20Completion.pdf>.

Paragamian VL, G Kruse and V Wakkinen. 2001. "Spawning Habitat of Kootenai River White Sturgeon, Post-Libby Dam." *North American Journal of Fisheries Management* 21(1):22-33. DOI: 10.1577/1548-8675(2001)021<0022:SHOKRW>2.0.CO;2.

Paragamian VL, G Kruse and VD Wakkinen. 1997. *Kootenai River White Sturgeon Investigations. Annual Progress Report FY 1996*. Project No. 88-6. Boise, ID: Idaho Department of Fish and Game. Contract No. DE-A179-88BP93497. Prepared for US Department of Energy, Bonneville Power Administration.

Paragamian VL, R McDonald, GJ Nelson and G Barton. 2009. "Kootenai River Velocities, Depth, and White Sturgeon Spawning Site Selection – A Mystery Unraveled?" *Journal of Applied Ichthyology* 25(6):640-646. DOI: 10.1111/j.1439-0426.2009.01364.x.

Paragamian VL and VD Wakkinen. 2011. "White sturgeon spawning and discharge augmentation." *Fisheries Management and Ecology* 18(4):314-321. DOI: 10.1111/j.1365-2400.2011.00785.x.

Partridge FE. 1983. *Kootenai River Fisheries Investigations in Idaho: Completion Report*, Boise, ID: Idaho Department of Fish & Game.

- Paulsen CM and TR Fisher. 2001. "Statistical relationship between parr-to-smolt survival of Snake River spring-summer Chinook salmon and indices of land use." *Transactions of the American Fisheries Society* 130(3):347-358. DOI: 10.1577/1548-8659(2001)130<0347:SRBPTS>2.0.CO;2.
- Pearcy WG. 2002. "Marine nekton off Oregon and the 1997–98 El Niño." *Progress in Oceanography* 54(1):399-403. DOI: 10.1016/S0079-6611(02)00060-5.
- Pess GR, R Hilborn, K Kloehn and TP Quinn. 2012. "The influence of population dynamics and environmental conditions on pink salmon (*Oncorhynchus gorbuscha*) recolonization after barrier removal in the Fraser River, British Columbia, Canada." *Canadian Journal of Fisheries and Aquatic Sciences* 69(5):970-982. DOI: 10.1139/f2012-030.
- Peterson JO, CA Morgan, WT Peterson and E Di Lorenzo. 2013. "Seasonal and interannual variation in the extent of hypoxia in the northern California current from 1998–2012." *Limnology and Oceanography* 58(6):2279-2292. DOI: 10.4319/lo.2013.58.6.2279.
- Petrosky CE and HA Schaller. 2010. "Influence of river conditions during seaward migration and ocean conditions on survival rates of Snake River Chinook salmon and steelhead." *Ecology of Freshwater Fish* 19(4):520-536. DOI: 10.1111/j.1600-0633.2010.00425.x.
- Peven CM, RR Whitney and KR Williams. 1994. "Age and length of steelhead smolts from the Mid-Columbia River basin, Washington." *North American Journal of Fisheries Management* 14(1):77-86. Hardcopy in MM's Library: NAJFM 14:77. DOI: 10.1577/1548-8675(1994)014<0077:AALOSS>2.3.CO;2.
- PFMC. 2019. *Review of 2018 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan*.
- Pierce R, C Podner and K Carim. 2013. "Response of wild trout to stream restoration over two decades in the Blackfoot River Basin, Montana." *Transactions of the American Fisheries Society* 142(1):68-81. DOI: 10.1080/00028487.2012.720626.
- Ploskey GR, MA Weiland and TJ Carlson. 2012. *Route-specific passage proportions and survival rates for fish passing through John Day Dam, The Dalles Dam, and Bonneville Dam in 2010 and 2011*. PNNL-21442. Interim report, Pacific Northwest National Laboratory, Richland, WA for the U.S. Army Corps of Engineers, Portland District, Contract No. DE-AC05-76RL01830. Available at https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21442.pdf.
- PNERC. 2002. *Willamette River Basin Planning Atlas: Trajectories of Environmental and Ecological Change. Version 2.0*. Eugene, OR: Pacific Northwest Ecosystem Research Consortium (PNERC), Institute for a Sustainable Environment, University of Oregon. Map available at <http://www.fsl.orst.edu/pnwerc/wrb/access.html> or http://www.fsl.orst.edu/pnwerc/wrb/Atlas_web_compressed/PDFtoc.html.
- PNNL/NMFS. 2018. *Restoration action effectiveness monitoring and research in the Lower Columbia River and Estuary, 2016-2017*. Portland, OR: Pacific Northwest National Laboratory (PNNL), National Marine Fisheries Service (NMFS). Progress report prepared for the U.S. Army Corps of Engineers, Portland District.
- Poe TP, HC Hansel, S Vigg, DE Palmer and LA Prendergast. 1991. "Feeding of predaceous fishes on out-migrating juvenile Salmonids in John Day Reservoir, Columbia River." *Transactions of the American Fisheries Society* 120(4):405-420. Main Library: 13288 [Discarded]. DOI: 10.1577/1548-8659(1991)120<0405:FOPFOO>2.3.CO;2.

Poe TP, M.G. Mesa, a R.S. Shively and RD Peters. 1994. "Development of biological criteria for siting and operation of juvenile bypass systems: implications for protecting juvenile salmonids from predation. Proceedings of a symposium on fish passage responsibility and technology. American Fisheries Society Annual Meeting 1993:169-176."

Polivka KM, EA Steel and JL Novak. 2015. "Juvenile salmon and steelhead occupancy of stream pools treated and not treated with restoration structures, Entiat River, Washington." *Canadian Journal of Fisheries and Aquatic Sciences* 72(2):166-174. DOI: 10.1139/cjfas-2014-0228.

PSC-CTC. 2018. *2017 Exploitation Rate Analysis and Model Calibration Volume Two: Appendix Supplement*. TCCHINOOK (18)-01 V.2. Pacific Salmon Commission (PSC)-Chinook Technical Committee (CTC). Available at <https://www.psc.org/download/35/chinook-technical-committee/10879/tcchinook-18-1-v2.pdf>.

PSMFC. 1992. *White Sturgeon Management Framework Plan*, Portland, OR: Pacific States Marine Fisheries Commission (PSMFC).

Quinn TP. 2005. *The behavior and ecology of pacific salmon and trout*, Bethesda, MA: American Fisheries Society. ISBN 9780295984575.

R. L. & L. Environmental Services Ltd. 1999. *Movements of white sturgeon in Kootenay Lake 1947–1997*. Bonneville Power Administration.

Rechisky EL, DW Welch, AD Porter, JE Hess and SR Narum. 2014. "Testing for delayed mortality effects in the early marine life history of Columbia River Basin yearling Chinook salmon." *Marine Ecology Progress Series* 496:159-180. DOI: 10.3354/meps10692.

Rechisky EL, DW Welch, AD Porter, MC Jacobs-Scott and PM Winchell. 2013. "Influence of multiple dam passage on survival of juvenile Chinook salmon in the Columbia River estuary and coastal ocean." *Proceedings of the National Academy of Sciences*. DOI: 10.1073/pnas.1219910110.

Rechisky EL, DW Welch, AD Porter, MC Jacobs and A Ladouceur. 2009. "Experimental measurement of hydrosystem-induced delayed mortality in juvenile Snake River spring Chinook salmon (*Oncorhynchus tshawytscha*) using a large-scale acoustic array." *Canadian Journal of Fisheries and Aquatic Sciences* 66(7):1019-1024. DOI: 10.1139/F09-078.

Reclamation. 2011. *SECURE Water Act Section 9503(c)—Reclamation Climate Change and Water. Report to Congress*. Denver, CO: U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center.

Reclamation, Corps and Bonneville. 2008. *Addendum to the "Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions": Analysis of Effects on Listed Killer Whale and Green Sturgeon Distinct Population Segments*. US Bureau of Reclamation (Reclamation), US Army Corps of Engineers (Corps), and Bonneville Power Administration (Bonneville). Available in NMFS' 2008 administrative record at B.0090.

Reynolds TD and CI Hinckley. 2005. *Final Report: A Survey for Yellow-billed Cuckoo in recorded historic and other likely locations in Idaho*. Idaho Bureau of Land Management Technical Bulletin 2005-05. Rigby, ID: TREC, Inc. Available at www.blm.gov/download/file/fid/22081.

Richards D. 1997. *Kootenai River Biological Baseline Status Report*. Project Number 94-49. Bonners Ferry, ID: Kootenai Tribe of Idaho. Prepared for U.S. Department of Energy, Bonneville Power Administration, Environment, Fish and Wildlife. Available at <https://www.cbfish.org/Document.mvc/DocumentViewer/40364-1/r40364-1.pdf>.

Ricklefs RE. 1990. *Ecology*, New York, NY: W. H. Freeman. ISBN 0716720779. 3rd Edition.

Rieman BE and JD McIntyre. 1993. *Demographic and Habitat Requirements for Conservation of Bull Trout*. General Technical Report INT-302. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. Available at [http://www.ybfwrp.org/Assets/Documents/References/Rieman McIntyre 1993.pdf](http://www.ybfwrp.org/Assets/Documents/References/Rieman_McIntyre_1993.pdf).

Rieman BE, R.C. Beamesderfer, S. Vigg and TP Poe. 1991. "Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. *Transactions of the American Fisheries Society* 120:448-458."

RMJOC. 2018. *Climate and hydrology datasets for RMJOC long-term planning studies: Second edition, (RMJOC-II) Part I: Hydroclimate projections and analyses*. River Management Joint Operating Committee (RMJOC). Produced by the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation. Available at <https://www.bpa.gov/p/Generation/Hydro/hydro/cc/RMJOC-II-Report-Part-I.pdf>.

Roby DD, K Collis, C Couch, G Dorsey, K Fischer, DE Lyons, AM Myers, SK Nelson, RM Suryan, A Evans and M Hawbecker. 2006. *Caspian tern research on the Lower Columbia River: Final 2003 season summary*. Portland, OR: Prepared for the Bonneville Power Administration and the Interagency Caspian Tern Working Group. This report is not for citation without permission of the authors. Available at http://www.birdresearchnw.org/03_Season_Summary.pdf.

Roby DD, K Collis, TJ Lawes, KS Bixler, DE Lyons, Y Suzuki, A Turecek and M Hawbecker. 2019. *Implementation and evaluation of efforts to reduce predation on ESA-listed salmonids by caspian terns nesting at East Sand Island, Columbia River Estuary: 2018 final annual report*. Portland, OR: Submitted to the Bonneville Power Administration and Northwest Power and Conservation Council. BPA Project no. 1997-024-00, Contract no. 60846. Available at http://www.birdresearchnw.org/2018_BPA_Final%20Annual%20Report.pdf.

Roby DD, K Collis, D Lyons, T Lawes, Y Suzuki, P Loschl, K Bixler, E Hanwacker, J Mulligan, A Munes, E Schniedermeier, A Evans, B Cramer, A Turecek, Q Payton and M Hawbecker. 2016. *Evaluation of foraging behavior, dispersal, and predation on ESA-listed salmonids by caspian terns displaced from managed colonies in the Columbia Plateau Region: 2015 Final annual report*. Ephrata, WA: Prepared for the Grant County PUD/Priest Rapids Coordinating Committee. Available at https://www.grantpud.org/templates/galaxy/images/images/Downloads/ResourceCommittees/OtherDocuments/FINAL_2015_GPUD_Report.pdf.

Roegner GC, R. McNatt, a D. J. Teel and DL Bottom. 2012. "Distribution, size, and origin of juvenile Chinook salmon in shallow-water habitats of the lower Columbia River and estuary, 2002-2007. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 4(1):450-472. DOI: 10.1080/19425120.2012.675982."

Romano MD, MD Howell and TA Rien. 2002. *Use of Artificial Substrate to Capture Eulachon (thaleichthys pacificus) Eggs in the Lower Columbia River*. Oregon Dept. of Fish and Wildlife, Clackamas, OR; and Washington Dept. of Fish and Wildlife, Vancouver, WA.

Roni P, K Hanson and T Beechie. 2008. "Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques." *North American Journal of Fisheries Management* 28(3):856-890. Hardcopy, TH's Library: NAJFM 28:856. DOI: 10.1577/M06-169.1.

Roni P, GR Pess, TJ Beechie and KM Hanson. 2014. *Fish-habitat relationships and the effectiveness of habitat restoration*, Seattle, WA: U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-127.

Rose GW. 2015. *Connecting Tidal-fluvial Life Histories to Survival of McKenzie River Spring Chinook Salmon (*Oncorhynchus tshawytscha*)*. M.S. Thesis, Oregon State University, Corvallis, OR. Available at https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/zc77st35f.

Ross et al. 2018. *Kootenai River Resident Fish Mitigation: White Sturgeon, Burbot, Native Salmonid Monitoring and Evaluation Annual Progress Report May 1, 2016 — April 31, 2017*. Portland, OR: Report by IDFG to the Bonneville Power Administration. Available at <https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/Res18-09Ross2018Kootenai%20River%20Resident%20Fish%20Mitigation.pdf>.

Ross TJ, P Rust and RS Hardy. 2015. *Kootenai River Resident Fish Mitigation: White Sturgeon, Burbot, and Native Salmonid Monitoring and Evaluation, Annual Progress Report, Project 1988-065-00*. Boise, ID: Idaho Department of Fish and Game. Prepared for Bonneville Power Administration.

RTT. 2014. *A biological strategy to protect and restore salmonid habitat in the Upper Columbia Region*. The Upper Columbia Regional Technical Team (RTT). A Draft Report to the Upper Columbia Salmon Recovery Board. .

Rust P, TJ Ross, R Hardy, D Wakkinen and J Hughes. 2014. *Kootenai River Resident Fish Mitigation: White Sturgeon, Burbot, and Native Salmonid Monitoring and Evaluation, Annual Progress Report, May 1, 2012-April 31, 2013*. IDFG Report Number 14-14. Boise, ID: Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Project 1988-065-00. Available at <https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/Res14-14Rust2013%20Kootenai%20River%20Resident%20Fish%20Mitigation.pdf>.

Ryan BA, EM Dawley and RA Nelson. 2000. "Modeling the Effects of Supersaturated Dissolved Gas on Resident Aquatic Biota in the Main-Stem Snake and Columbia Rivers." *North American Journal of Fisheries Management* 20(1):192-204. DOI: 10.1577/1548-8675(2000)020<0192:MTEOSD>2.0.CO;2.

Salo EO. 1991. "Life history of chum salmon (*Oncorhynchus keta*). In Pacific Salmon Life Histories. Ed. C. Groot and L. Margolis, UBC Press, Vancouver B.C."

Sanderson BL, KA Barnas and AMW Rub. 2009. "Nonindigenous Species of the Pacific Northwest: An Overlooked Risk to Endangered Salmon?" *BioScience* 59(3):245-256. DOI: 10.1525/bio.2009.59.3.9.

Sandford BP, RW Zabel, LG Gilbreath and SG Smith. 2012. "Exploring Latent Mortality of Juvenile Salmonids Related to Migration through the Columbia River Hydropower System." *Transactions of the American Fisheries Society* 141(2):343-352. DOI: 10.1080/00028487.2012.664601.

Schaller HA, CE Petrosky and ES Tinus. 2013. "Evaluating river management during seaward migration to recover Columbia River stream-type Chinook salmon considering the variation in marine conditions." *Canadian Journal of Fisheries and Aquatic Sciences* 71(2):259-271. DOI: 10.1139/cjfas-2013-0226.

Scheuerell MD and JG Williams. 2005. "Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*)." *Fisheries Oceanography* 14(6):448-457. DOI: 10.1111/j.1365-2419.2005.00346.x.

Scheuerell MD, RW Zabel and BP Sandford. 2009. "Relating Juvenile Migration Timing and Survival to Adulthood in Two Species of Threatened Pacific Salmon (*Oncorhynchus spp.*)." *Journal of Applied Ecology* 46(5):983-990. DOI: 10.1111/j.1365-2664.2009.01693.x.

Schiff D and E Schreiver. 2004. *Bull Trout Life History Investigations in the North Fork Clearwater River Basin. Annual Report, 2002*. Boise, ID: Idaho Department of Fish and Game.

Schiff D, E Schriever and J Peterson. 2005. *Bull trout life history investigations in the North Fork Clearwater River Basin. Regional fisheries management investigations, North Fork Clearwater River bull trout*. Drumore, PA: Normandeau Associates. Contract No. DACW68-96-D-003, Delivery Order 0022.

Schneider M. 2011. *Total Dissolved Gas Exchange at Chief Joseph Dam: Post Spillway Flow Deflectors, April 28–May 1, 2009 Draft Report*. Vicksburg, MS: U.S. Army Engineer Research and Development Center (ERDC). Prepared for the Seattle District Corps of Engineers.

Schneider ML and K Barko. 2006. *Total dissolved gas characterization of the lower Columbia River below Bonneville Dam*. Draft report prepared for the U.S. Army Corps of Engineers, Portland, OR by the U.S. Army Corps of Engineers, Engineer Research and Development Center, Dallesport, WA. Available at http://pweb.crohms.org/tmt/wq/studies/TDG_Char_LCR_below_BON-1Mar06.pdf.

Schreck CB, TP Stahl, LE Davis, DD Roby and BJ Clemens. 2006. "Mortality Estimates of Juvenile Spring–Summer Chinook Salmon in the Lower Columbia River and Estuary, 1992–1998: Evidence for Delayed Mortality?" *Transactions of the American Fisheries Society* 135(2):457-475. DOI: 10.1577/T05-184.1.

Schreier A, OP Langness, JA Israel and E Van Dyke. 2016. "Further investigation of green sturgeon (*Acipenser medirostris*) distinct population segment composition in non-natal estuaries and preliminary evidence of Columbia River spawning." *Environmental Biology of Fishes* 99(12):1021-1032. DOI: 10.1007/s10641-016-0538-1.

Scordino J. 2010. *West Coast pinniped program investigations on California sea lion and Pacific harbor seal impacts on salmonids and other fishery resources*. Portland, OR: Pacific States Marine Fisheries Commission. Available at http://dev.psmfc.org/wp-content/uploads/2012/01/expand_pinniped_report_2010.pdf.

Scott WB and EJ Crossman. 1973. *Freshwater fishes of Canada*. Bulletin 184. Ottawa, Ontario: Fisheries Research Board of Canada.

Selong JH, TE McMahon, AV Zale and FT Barrows. 2001. "Effect of Temperature on Growth and Survival of Bull Trout, with Application of an Improved Method for Determining Thermal Tolerance in Fishes." *Transactions of the American Fisheries Society* 130(6):1026-1037. DOI: 10.1577/1548-8659(2001)130<1026:EOTOGA>2.0.CO;2.

Simenstad CA, KL Fresh and EO Salo. 1982. "The Role of Puget Sound and Washington Coastal Estuaries in the Life History of Pacific Salmon: An Unappreciated Function." In *Estuarine Comparisons*, pp. 343-364. ed: VS Kennedy. New York, NY: Academic Press. DOI: 10.1016/B978-0-12-404070-0.50026-0.

Simenstad CA, LF Small and C David McIntire. 1990. "Consumption processes and food web structure in the Columbia River estuary." *Progress in Oceanography* 25(1):271-297. DOI: [https://doi.org/10.1016/0079-6611\(90\)90010-Y](https://doi.org/10.1016/0079-6611(90)90010-Y).

Simpson JC and RL Wallace. 1978. *Fishes of Idaho*, Moscow, ID: University of Idaho Press.

Skaar D, J DeShazer, L Garrow, T Ostrowski and B Thornberg. 1996. *Quantification of Libby Reservoir Levels Needed to Enhance Reservoir Fisheries. Investigations of Fish Entrainment Through Libby Dam, 1990–1994. Final Report*. Project Number 83-467. Kalispell, MT: Montana Department of Fish, Wildlife and Parks - Region 1. Prepared for Bonneville Power Administration.

Skalski JR, R Townsend, J Lady, AE Giorgi, JR Stevenson and RD McDonald. 2002. "Estimating route-specific passage and survival probabilities at a hydroelectric project from smolt radiotelemetry studies." *Canadian Journal of Fisheries and Aquatic Science* 59(8):1385-1393. DOI: 10.1139/f02-094.

Skalski JR, RL Townsend, AG Seaburg, GA McMichael, RA Harnish, EW Oldenburg, KD Ham, AH Colotelo, KA Deters, ZD Deng, PS Titzler, EV Arntzen and CR Vernon. 2014. *Final BiOp performance testing: passage and survival of subyearling Chinook salmon at Little Goose and Lower Monumental Dams, 2013*. PNNL-22706. Richland, WA: Pacific Northwest National Laboratory. Prepared for the U.S. Army Corps of Engineers, Walla Walla District, Contract No. W912EF-08-D-004. Available at https://www.researchgate.net/publication/267328782_BiOp_Performance_Testing_Passage_and_Survival_of_Subyearling_Chinook_Salmon_at_Little_Goose_and_Lower_Monumental_Dams_2013_FINAL_BiOp_Performance_Testing_Report.

Skalski JR, MA Weiland, KD Ham, GR Ploskey, GA McMichael, AH Colotelo, TJ Carlson, CM Woodley, MB Eppard and EE Hockersmith. 2016. "Status after 5 years of survival compliance testing in the Federal Columbia River Power System (FCRPS)." *North American Journal of Fisheries Management* 36(4):720-730. DOI: 10.1080/02755947.2016.1165775.

Smith SG, DM Marsh, RL Emmett, WD Muir and RW Zabel. 2013. *A study to determine seasonal effects of transporting fish from the Snake River to optimize a transportation strategy*. Report of research by Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, NOAA. Prepared for U.S. Army Corps of Engineers, Walla Walla District, Northwestern Division.

Smith SG, TM Marsh and WP Connor. 2018. *Responses of Snake River Fall Chinook Salmon to Dam-Passage Strategies and Experiences*. Walla Walla, WA: Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service and Idaho Fish and Wildlife Conservation Office, U.S. Fish and Wildlife Service for the Walla Walla District, Northwest Division, U.S. Army Corps of Engineers. Available at https://www.nwfsc.noaa.gov/assets/26/8240_11162018_154745_Fall%20Chinook%20Transportation%202018.pdf.

Smith SG, WD Muir, EE Hockersmith, RW Zabel, RJ Graves, CV Ross, WP Connor and BD Arnsberg. 2003. "Influence of river conditions on survival and travel time of Snake River subyearling fall Chinook salmon." *North American Journal of Fisheries Management* 23(3):939-961. Hardcopy: TH's Library, NAJFM 23:939. DOI: 10.1577/M02-039.

Smith WE and RW Saalfeld. 1955. "Studies on Columbia River Smelt (*Thaleichthys pacificus*) (Richardson)." *Fisheries Research Papers* 1(3):3-26.

Snow C, C Frady, D Grundy, B Goodman and A Haukenes. 2018. *Monitoring and evaluation of the Wells hatchery and Methow hatchery programs: 2017 annual report*. East Wenatchee, WA: Report to Douglas PUD, Grant PUD, Chelan PUD, and the Wells and Rocky Reach HCP Hatchery Committees, and the Priest rapids Hatchery Subcommittees. Available at https://douglaspud.org/HCP%20HC%20Documents/2018_11_02%20Douglas%20-%20Final%202017%20DCPUD%20Annual%20M%20and%20E%20Report.pdf.

Sorel MH, AM Wargo Rub and RW Zabel. 2017. *Population-specific migration timing affects en route survival of Chinook salmon through a variable lower-river corridor*. Ocean Associates Inc. for NMFS (Northwest Fisheries Science Center). Final Report and Recommendations Bonneville Pinniped-Fishery Interaction Task Force Marine Mammal Protection Act, Section 120, April 2017. Available at https://archive.fisheries.noaa.gov/wcr/publications/protected_species/marine_mammals/pinnipeds/sea_lion_removals/2017/appendix_c_population-specific_migration_timing_effects_on_route_survival_of_chinook_salmon.pdf.

Steigenberger LW and PA Larkin. 1974. "Feeding activity and rates of digestion of northern squawfish (*Ptychocheilus oregonensis*). *Journal of Fisheries Research Board of Canada* 31(4):411-420."

Stevenson JR, DJ Snyder, SJ Mallas and P Westhagen. 2008. *Movements of radio-tagged bull trout through Rocky Reach and Rock Island dams and reservoirs: 2007. Annual Report*. Boise, ID: BioAnalysts, Inc.

Stevenson JR, DJ Snyder, SJ Mallas and P Westhagen. 2009. *Movements of radio-tagged bull trout through Rocky Reach and Rock Island dams and reservoirs: 2008. Annual Report*. Boise, ID: BioAnalysts, Inc.

Stevenson JR, DJ Snyder and P Westhagen. 2006. *Bull trout radio telemetry monitoring associated with up and downstream passage through Rocky Reach and Rock Island dams and reservoirs, 2005*. Boise, ID: BioAnalysts, Inc.

Stevenson JR, DJ Snyder and P Westhagen. 2007. *Movements of radio-tagged bull trout through Rocky Reach and Rock Island dams and reservoirs: 2006. Annual report*. Boise, ID: BioAnalysts, Inc.

Stinson DW. 2005. *Washington State status report for the Mazama pocket gopher, streaked horned lark, and Taylor's checkerspot*. Olympia, WA: Washington Department of Fish and Wildlife, Olympia.

Sturdevant MV. 1999. *Forage Fish Diet Overlap, 1994-1996. Exxon Valdez Oil Spill, Restoration Project Final Report (Restoration Project 98163C), Final Report*. Juneau, Alaska: Auke Bay Laboratory, National Marine Fisheries Service.

Sylvester R and B Stephens. 2011. *Evaluation of the Physical and Biological Effects of the Northwest Power Conservation Council's Mainstem Amendment Upstream and Downstream of Libby Dam, Montana: Annual Report July 1, 2009 – June 30, 2010*. Report prepared by Montana Fish, Wildlife & Parks for Bonneville Power Administration. Available at <https://www.cbfish.org/Document.mvc/Viewer/P121657>.

Sylvester RM, BC Stephens and JT Frye. 2016. *Mainstem Columbia Amendments Research at Libby Dam, 1/1/2015 - 12/31/2015 Annual Report*. 2006-008-00. Report prepared by Montana Fish, Wildlife & Parks for Bonneville Power Administration. Available at <https://www.cbfish.org/Document.mvc/Viewer/P149429>.

Sylvester RM, BC Stephens and JT Frye. 2019. *Mainstem Columbia Amendments Research at Libby Dam, 1/1/2018 - 12/31/2018 Annual Report*. BPA Project # 2006-008-00. Libby, MT: Montana Fish, Wildlife & Parks. Report prepared for Bonneville Power Administration. Available at <https://www.cbfish.org/Document.mvc/Viewer/P164102>.

Tabor RA, RS Shively and TP Poe. 1993. "Predation on juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington." *North American Journal of Fisheries Management* 13(4):831-838. DOI: 10.1577/1548-8675(1993)013<0831:POJSBS>2.3.CO;2.

TAC. 2017. *2018–2027 U.S. v. Oregon Biological Assessment of Incidental Impacts on Species Listed Under the Endangered Species Act Affected by the 2018-2027 U.S. v. Oregon Management Agreement*. Technical Advisory Committee (TAC). 6/21/2017.

Taylor DM. 2000. "Status of the Yellow-billed Cuckoo in Idaho." *Western Birds* 31:252-254.

Teel DJ, DL Bottom, SA Hinton, DR Kuligowski, GT McCabe, R McNatt, GC Roegner, LA Stamatiou and CA Simenstad. 2014. "Genetic identification of Chinook salmon in the Columbia River Estuary: Stock-specific distributions of juveniles in shallow tidal freshwater habitats." *North American Journal of Fisheries Management* 34(3):621-641. DOI: 10.1080/02755947.2014.901258.

Tetra Tech. 2002. *Sammamish River Corridor Action Plan*. Seattle, WA: Tetra Tech, Inc. Prepared for the US Army Corps of Engineers and King County DNR and Parks. Available at <http://green.kingcounty.gov/WLR/Waterres/StreamsData/reports/sammrivercorridoractionplan.aspx>.

Thorson TD, SA Bryce, DA Lammers, AJ Woods, JM Omernik, J Kagan, DE Pater and JA Comstock. 2003. "Ecoregions of Oregon." Reston, VA: U.S. Geological Survey. Available at <http://people.oregonstate.edu/~muirp/FuelsReductionSWOregon/ToolsResources/EcoregionsOregonLevellVEPA.pdf>. Color poster with map, descriptive text, summary tables, and photographs. Map scale 1:1,500,000.

Color poster with map, descriptive text, summary tables, and photographs. Map scale 1:1,500,000.

Thurrow RF. 1987. *Evaluation of the South Fork Salmon River steelhead trout fishery restoration program*. Boise, ID: Idaho Dept. of Fish and Game. Completion report. Contract no. 14-16-0001-86505. Available at <https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/Res-Thurrow1986%20Evaluation%20of%20the%20South%20Fork%20Salmon%20River%20Steelhead%20Trout%20Fishery%20Restoration%20Program.pdf>.

Tidwell KS, BA Carrothers, KN Bayley, LN Magill and BK van der Leeuw. 2019. *Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2018*. Cascade Locks, OR: U.S. Army Corps of Engineers, Portland District Fisheries Field Unit. Available at <http://pweb.crohms.org/tmt/documents/FPOM/2010/Task%20Groups/Task%20Group%20Pinnipeds/>.

Tidwell KS, BK van der Leeuw, LN Magill, BA Carrothers and RH Wertheimer. 2018. *Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2017*. Cascade Locks, OR: U.S. Army Corps of Engineers, Portland District Fisheries Field Unit. Available at <http://pweb.crohms.org/tmt/documents/FPOM/2010/Task%20Groups/Task%20Group%20Pinnipeds/>.

Tinus ES and RC Beamesderfer. 1994. *An update on the distribution, fisheries, and biology of walleye in the lower Columbia River*. Information Report No. 94-3. Clackamas, OR: Oregon Department of Fish and Wildlife. Available at <https://nrimp.dfw.state.or.us/CRL/Reports/Info/94-3.pdf>.

Tippery S, KK Jones, KJ Anlauf, CH Stein and M Strickland. 2010. *Effectiveness Monitoring Report for the Western Oregon Stream Restoration Program, 1999-2008*. Salem, OR: Oregon Department of Fish and Wildlife, Report No. OPSW-ODFW-2010-6. https://odfw.forestry.oregonstate.edu/freshwater/inventory/rest_reports.htm. Available at <https://odfw.forestry.oregonstate.edu/freshwater/inventory/pdffiles/Effectiveness%20of%20WOSRP%201999-2008%20OPSW%202010-6%20Final.pdf>.

Tucker S, ME Thiess, JFT Morris, D Mackas, WT Peterson, JR Candy, TD Beacham, EM Iwamoto, DJ Teel, M Peterson and M Trudel. 2015. "Coastal distribution and consequent factors influencing production of endangered Snake River Sockeye salmon." *Transactions of the American Fisheries Society* 144(1):107-123. DOI: 10.1080/00028487.2014.968292.

Turecek A, J Tennyson, K Collis and B Cramer. 2018. *Final Annual Report: Double-Crested Cormorant Monitoring on East Sand Island, 2017*. IDIQ Contract No. W912EF-14-0004. Portland, OR: Real Time Research, Inc. Prepared for the U.S. Army Corps of Engineers, Portland District. Available at <https://usace.contentdm.oclc.org/utills/getfile/collection/p16021coll3/id/791>.

2008. "2008-2017 *United States v. Oregon* Management Agreement." District of Oregon, Civil No. 68-513-KI (Aug. 12, 2008) (Doc. No. 2546). Available at https://www.fws.gov/pacific/fisheries/hatcheryreview/Reports/snakeriver/SR--079.revised.2008-17USvOR_Mngmt_Agrmt.pdf.

2018. "2018-2027 *United States v. Oregon* Management Agreement." Civil No. 68-513-MO (D. Or.), Document No. 2607-1, Filed 02/26/18. Available at <https://www.fws.gov/lsnakecomplan/Reports/USvOregon/FINAL.2018-%202027%20USvOR%20Management%20Agreement%20with%20Signature%20Feb%202018%20.pdf>.
- UCSRB. 2007. *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan*. Wenatchee, WA: Upper Columbia Salmon Recovery Board (UCSRB). Available at http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/upper_columbia/uc_plan.pdf.
- UCSRB. 2014. *Integrated Recovery Program Habitat Report*. Wenatchee, WA: Upper Columbia Salmon Recovery Board (UCSRB). Available at <http://www.ucsrb.org/>.
- UCSRB. 2019. *Upper Columbia Integrated Recovery Hydropower Background Summary*. Wenatchee, WA: Upper Columbia Salmon Recovery Board (UCSRB). Available at <https://www.ucsrb.org/?mdocs-file=4048>.
- USACE and BPA. 2011. *Albeni Falls Dam Flexible Winter Power Operations, Bonner County, Idaho: Final Environmental Assessment*. U.S. Army Corps of Engineers and Bonneville Power Administration. Available at https://www.bpa.gov/efw/Analysis/NEPADocuments/nepa/AFD-FWPO/AFD_FWPO_Final_EA.pdf.
- USFWS. 1983. *Revised Columbian white-tailed deer recovery plan*. Portland, OR: U.S. Fish and Wildlife Service (USFWS).
- USFWS. 1999. *Recovery Plan for the Kootenai River Population of the White Sturgeon (Acipenser transmontanus)* Portland, Oregon: Region 1, U.S. Fish and Wildlife Service. Available at http://www.krisweb.com/biblio/kootenai_usfws_region1_1999_sturgrecov.pdf.
- USFWS. 2002a. "Chapter 13, Hells Canyon Complex Management Unit, Oregon and Idaho." In *Bull Trout (Salvelinus confluentus) Draft Recovery Plan*. Portland, OR: U.S. Fish and Wildlife Service (USFWS). Available at https://www.fws.gov/pacific/bulltrout/rp/chapter_13%20hells%20canyon.pdf.
- USFWS. 2002b. "Chapter 16, Clearwater River Recovery Unit, Idaho." In *Bull Trout (Salvelinus confluentus) Draft Recovery Plan*. Portland, OR: U.S. Fish and Wildlife Service (USFWS). Available at https://www.fws.gov/pacific/bulltrout/RP/Chapter_16%20Clearwater.pdf.
- USFWS. 2005. *Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary: Final Environmental Impact Statement*. Portland, OR: U.S. Fish and Wildlife Service (USFWS). Available at https://www.fws.gov/pacific/migratorybirds/pdf/Caspian_Tern_Final_EIS.pdf.
- USFWS. 2006. *Biological Opinion Regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat*. Washington, D.C.: U.S. Fish and Wildlife Service (USFWS). February 18, 2006. Available at <https://www.salmonrecovery.gov/Files/BiologicalOpinions/2008/Final%20Libby%20Dam%20BiOp%202-18-06lr3.pdf>.
- USFWS. 2010. *Bull Trout Final Critical Habitat Justification: Rationale for Why Habitat Is Essential, and Documentation of Occupancy*. Boise, ID: U.S. Fish & Wildlife Service, Idaho Fish and Wildlife Office. Available at <https://www.fws.gov/pacific/bulltrout/pdf/Justification%20Docs/BTFinalJustifyfull.doc.pdf>.
- USFWS. 2013. *Formal section 7 programmatic consultation on BPA's Columbia River Basin Habitat Improvement Program (HIP III)*. Portland, OR: U.S. Fish and Wildlife Service (USFWS), Oregon Fish and

- Wildlife Office. TAILS No. 01EOFW00-2013-F-0199. Available at https://www.bpa.gov/efw/Analysis/NEPADocuments/esa/USFWS_HIP_III_BO_Signed_FINAL.pdf.
- USFWS. 2014. *Revised Draft Recovery Plan for the Coterminous United States Population of Bull Trout (Salvelinus confluentus)*. Portland, OR: U.S. Fish and Wildlife Service (USFWS). Available at <https://www.fws.gov/pacific/bulltrout/pdf/Revised%20Draft%20Bull%20Trout%20Recovery%20Plan.pdf>.
- USFWS. 2015a. *Coastal Recovery Unit Implementation Plan for Bull Trout (Salvelinus confluentus)*. Lacey, WA: U.S. Fish and Wildlife Service. Available at https://www.fws.gov/pacific/bulltrout/pdf/Final_Coastal_RUIP_092915.pdf.
- USFWS. 2015b. *Columbia headwaters recovery unit implementation plan for bull trout (Salvelinus confluentus)*. U.S. Fish and Wildlife Service, Kalispell, Montana, and Spokane, Washington. Available at https://douglaspudd.org/ASA%20Documents/Wells_Project_%20Bull_Trout_MP.pdf.
- USFWS. 2015c. *Draft Mid-Columbia Recovery Unit Implementation Plan for Bull Trout Recovery Plan*. Portland, OR: U.S. Fish and Wildlife Service (USFWS). Available at https://www.fws.gov/pacific/ecoservices/endangered/recovery/documents/Draft_Mid_Columbia_RUIP_060215.pdf.
- USFWS. 2015d. *Mid-Columbia Recovery Unit Implementation Plan for Bull Trout Recovery Plan*. Portland, OR: U.S. Fish and Wildlife Service (USFWS).
- USFWS. 2015e. *Recovery Plan for the Coterminous United States Population of Bull Trout (Salvelinus confluentus)*. Portland, OR: U.S. Fish and Wildlife Service (USFWS). Available at <http://www.fws.gov/pacific/ecoservices/endangered/recovery/plans.html> and <http://www.fws.gov/endangered/species/recovery-plans.html>.
- USFWS. 2018. *Biological opinion for the issuance of two section 10(a)(1)(a) permits, and continued funding, operation, maintenance, monitoring, and evaluation of the Snake River Sockeye Salmon Hatchery Program and operation and maintenance of its associated facilities. 01EIFW00-2017-F-0819*. Boise, ID: U.S. Fish and Wildlife Service (USFWS). Produced for the National Marine Fisheries Service (NMFS) and Bonneville Power Administration (BPA) by the USFWS. Available at https://www.fws.gov/idaho/documents/BOs/SockeyeHatcheryProgram_BO.pdf.
- USFWS. 2019. *Revised Recovery Plan for the Kootenai River Distinct Population Segment of the White Sturgeon*. Portland, OR: U.S. Fish and Wildlife Service (USFWS).
- USFWS and NMFS. 2018. *Biological Opinion for the Albeni Falls Dam Fish Passage Project*. FWS Reference: 01EIFW00-F-0259. Available at <https://www.fws.gov/idaho/documents/BOs/AFD%20passage%20FINAL%20signed%20BO.pdf>.
- USGCRP. 2017. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. eds: DJ Wuebbles, DW Fahey, KA Hibbard, DJ Dokken, BC Stewart and TK Maycock, Washington, DC: U.S. Global Change Research Program (USGCRP). https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.
- Vigg A and CC Burley. 1991. "Temperature dependent maximum daily consumption of juvenile salmonids by northern squawfish (*Ptychocheilus oregonensis*) from the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 48:2491-2498."

Vigg S, T.P. Poe, L.A. Prendergast and HC Hansel. 1991. "Rates of consumption of juvenile salmonids and alternate prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. *Transactions of the American Fisheries Society* 120:421-438."

Walters AW, T Copeland and DA Venditti. 2013. "The density dilemma: limitations on juvenile production in threatened salmon populations." *Ecology of Freshwater Fish* 22(4):508-519. USA public domain. DOI: 10.1111/eff.12046.

Wargo Rub AM, LG Gilbreath, RL McComas, BP Sandford, DJ Teel and JW Ferguson. 2012a. *Estimated survival of adult spring/summer Chinook salmon from the mouth of the Columbia River to Bonneville Dam, 2010*. Seattle, WA: National Marine Fisheries Service, Northwest Fisheries Science Center. Available at <https://www.nwfsc.noaa.gov/research/divisions/fe/documents/adult-survival-2010.pdf>.

Wargo Rub AM, LG Gilbreath, RL McComas, BP Sandford, DJ Teel and JW Ferguson. 2012b. *Survival of adult spring/summer Chinook salmon from the mouth of the Columbia River to Bonneville Dam, 2011*. Seattle, WA: National Marine Fisheries Service, Northwest Fisheries Science Center. Available at <https://www.nwfsc.noaa.gov/research/divisions/fe/documents/adult-survival-2011.pdf>.

Wargo Rub AM, NA Som, MJ Henderson, BP Sandford, DM Van Doornik, DJ Teel, MJ Tennis, OP Langness, BK van der Leeuw and DD Huff. 2019. "Changes in adult Chinook salmon (*Oncorhynchus tshawytscha*) survival within the lower Columbia River amid increasing pinniped abundance." *Canadian Journal of Fisheries and Aquatic Sciences* 76(10):1862-1873. DOI: 10.1139/cjfas-2018-0290.

WDF. 1938. *Report of the Preliminary Investigations Into the Possible Methods of Preserving the Columbia River Salmon and Steelhead at the Grand Coulee Dam*. The State of Washington, Department of Fisheries (WDF). Available at <https://www.usbr.gov/pn/grandcoulee/history/natural/1938salmon.pdf>.

WDFW/ODFW. 2001. *Washington and Oregon Eulachon Management Plan*. Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW). Available at <https://wdfw.wa.gov/sites/default/files/publications/00849/wdfw00849.pdf>.

WDFW/ODFW. 2008. *Summary of Questions and Requested Information*. Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW).

WDOE. 2013. "Water Quality Assessment for Washington. 303(d)/305(b) Integrated Report Viewer." Washington Department of Ecology (WDOE). Accessed September 27, 2013. Available at <http://apps.ecy.wa.gov/wats/Default.aspx>. Online database.

Weitkamp DE and M Katz. 1980. "A review of dissolved gas supersaturation literature." *Transactions of the American Fisheries Society* 109(6):659-702. TH's Library Call No. W51 [Discarded]. BioAnalysts Library Call No. 5570 [Discarded]. DOI: 10.1577/1548-8659(1980)109<659:ARODGS>2.0.CO;2.

Weitkamp L. 2018. "Were SR fall Chinook in the AEMR landscape tows subyearlings or yearlings?". Communication to L. Krasnow (NMFS), 7/18/2018.

Weitkamp L, G Goulette, J Hawkes, M O'Malley and C Lipsky. 2014. "Juvenile salmon in estuaries: Comparisons between North American Atlantic and Pacific salmon populations." *Reviews in Fish Biology and Fisheries* 24(3):713-736. DOI: 10.1007/s11160-014-9345-y.

Weitkamp LA, PJ Bentley and MNC Litz. 2012. "Seasonal and interannual variation in juvenile salmonids and associated fish assemblage in open waters of the lower Columbia River estuary." *Fishery Bulletin* 110(4):426-450.

Welch DW, AD Porter and EL Rechisky. 2018. "The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow moving catastrophe or deeper failure? [Pre-print]." *bioRxiv*:476408. DOI: 10.1101/476408.

Wentz DA, BA Bonn, KD Carpenter, SR Hinkle, ML Janet, FA Rinella, MA Unrich, IR Waite, A Laenen and KE Bencala. 1998. *Water Quality in the Willamette Basin, Oregon, 1991–95*. U.S. Geological Survey Circular 1161. Portland, OR: U.S. Department of the Interior, U.S. Geological Survey. Available at https://people.wou.edu/~taylors/Monmouth_Hydrogeology/wentz_et al_1998.pdf.

Werner K, RW Zabel, DD Huff and BJ Burke. 2017. Memorandum to M. Tehan, Assistant Regional Administrator, Interior Columbia Basin Office. "Ocean Conditions and Salmon Returns for 2017-2018." August 18, 2017. Seattle, WA: Northwest Fisheries Science Center.

White SL, C Gowan, KD Fausch, JG Harris and WC Saunders. 2011. "Response of trout populations in five Colorado streams two decades after habitat manipulation." *Canadian Journal of Fisheries and Aquatic Science* 68(12):2057-2063. DOI: 10.1139/f2011-125.

Widener DL, JR Faulkner, SG Smith, TM Marsh and RW Zabel. 2018. *Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2017*. Report of research by the Northwest Fisheries Science Center, Seattle, WA for the Bonneville Power Administration, Contract No. 40735, Project No. 199302900, Portland, OR. Available at https://www.nwfsc.noaa.gov/assets/26/9359_02262018_135356_Widener.et.al.2018-Spring-Survival-2017.pdf.

Widener DL, JR Faulkner, SG Smith, TM Marsh and RW Zabel. 2019. *Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2018*. Report of research by the Northwest Fisheries Science Center, Seattle, WA for the Bonneville Power Administration, Contract No. 40735, Project No. 199302900, Portland, OR. Available at https://www.nwfsc.noaa.gov/assets/26/9634_09252019_111835_Widener.et.al.2019-Spring-Survival-2018.pdf.

Wiles GJ and KS Kalasz. 2017. *Status report for the Yellow-billed Cuckoo in Washington*. Olympia, WA: Washington Department of Fish and Wildlife.

Williams JG, RW Zabel, RS Waples, JA Hutchings and WP Connor. 2008. "Potential for anthropogenic disturbances to influence evolutionary change in the life history of a threatened salmonid." *Evolutionary Applications* 1(2):271-285. TH's Library Call No. W335 [Discarded]. DOI: 10.1111/j.1752-4571.2008.00027.x.

Williams S, E Winther and CM Barr. 2017. *Report on the predation index, predator control fisheries, and program evaluation for the Columbia River Basin northern pikeminnow sport reward program: 2016 annual report*. Portland, OR: Bonneville Power Administration, Project No. 1990-077-00, Contract No. 71866, Document ID P154737. Available at <https://www.cbfish.org/Document.mvc/Viewer/P154737>.

Williams S, E Winther, CM Barr and C Miller. 2019. *Report on the predation index, predator control fisheries, and program evaluation for the Columbia River Basin northern pikeminnow sport reward program: 2018 annual report, April 1, 2018 thru March 31, 2019*. Document ID P165604. Portland, OR: Pacific States Marine Fisheries Commission, Washington Dept. of Fish and Wildlife, and Oregon Dept. of Fish and Wildlife. Project No. 1990-077-00, Contract No. 71866 and 78040 REL 3. Available at <https://www.cbfish.org/Document.mvc/Viewer/P165604>.

Woods PF and CM Falter. 1982. *Limnological Investigations: Lake Koocanusa, Montana, Part 4, Factors Controlling Primary Productivity*. Seattle, WA: U.S. Army Corps of Engineers, Seattle District.

Wright B, T Murtagh, C Owen, K Sandoval and T Tillson. 2018. *Willamette Falls Pinniped Monitoring Project, 2018*. Oregon Department of Fish and Wildlife. Available at [https://www.dfw.state.or.us/fish/sealion/docs/Willamette Falls 2018 Sea Lion Report.pdf](https://www.dfw.state.or.us/fish/sealion/docs/Willamette_Falls_2018_Sea_Lion_Report.pdf).

Zabel R and T Cooney. 2014. "Appendix C: Recruits-per-spawner in base versus current time periods—do they differ?" In *2014 FCRPS Supplemental Biological Opinion*, p. 36 NOAA Fisheries.

Zabel RW. 2018. Letter to RJ Graves. "Preliminary survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs." Seattle, WA: NOAA, Northwest Fisheries Science Center.

Zabel RW and S Achord. 2004. "Relating size of juveniles to survival within and among populations of Chinook salmon." *Ecology* 85(3):795-806. Hardcopy, TH's Library: ECOL 85:795. DOI: 10.1890/02-0719.

Zabel RW, J Faulkner, SG Smith, JJ Anderson, CV Holmes, N Beer, S Iltis, J Krinke, G Fredricks, B Bellerud, J Sweet and A Giorgi. 2008. "Comprehensive passage (COMPASS) model: a model of downstream migration and survival of juvenile salmonids through a hydropower system." *Hydrobiologia* 609(1):289-300. DOI: 10.1007/s10750-008-9407-z.

Zabel RW, MD Scheuerell, MM McClure and JG Williams. 2006. "The interplay between climate variability and density dependence in the population viability of Chinook salmon." *Conservation Biology* 20(1):190-200. TH's Library Z23. [Discarded]. DOI: 10.1111/j.1523-1739.2005.00300.x.

Zhang L and TL Delworth. 2016. "Simulated response of the Pacific decadal oscillation to climate change." *Journal of Climate* 29(16):5999-6018. DOI: 10.1175/JCLI-D-15-0690.1.

Zubik RJ and JJ Fraley. 1987. *Determination of Fishery Losses in the Flathead System Resulting from the Construction of Hungry Horse Dam*. Kalispell, MT: Montana Department of Fish, Wildlife & Parks. Prepared for Bonneville Power Administration, Portland, OR.

4 SUMMARY AND CONCLUSION

4.1 DETERMINATION OF EFFECTS

Based on this review of the potential for effects on species listed under the ESA and their designated critical habitat from the Proposed Action, Table 4-1 and Table 4-2 provide the Action Agencies' determination of effects for each species and designated critical habitat.

Table 4-1. Determination of effects from the Proposed Action on ESA-listed species and designated critical habitat under NMFS jurisdiction

Evolutionarily Significant Unit/Distinct Population Segment	ESA Status	Determination for Species	Determination for Critical Habitat
Snake River Sockeye Salmon ESU (<i>Oncorhynchus nerka</i>)	E	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Snake River Fall-run Chinook Salmon ESU (<i>O. tshawytscha</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Snake River Spring/Summer-run Chinook Salmon ESU (<i>O. tshawytscha</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Snake River Steelhead DPS (<i>O. mykiss</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Upper Columbia River Steelhead DPS (<i>O. mykiss</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Lower Columbia River Steelhead DPS (<i>O. mykiss</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Upper Columbia River Spring-run Chinook Salmon ESU (<i>O. tshawytscha</i>)	E	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Upper Columbia River Chinook Salmon ESU (<i>O. tshawytscha</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Upper Willamette River Chinook Salmon ESU (<i>O. tshawytscha</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Columbia River Chum Salmon ESU (<i>O. keta</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect

Evolutionarily Significant Unit/Distinct Population Segment	ESA Status	Determination for Species	Determination for Critical Habitat
Mid-Columbia River Steelhead DPS (<i>O. mykiss</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Upper Willamette River Steelhead DPS (<i>O. mykiss</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Lower Columbia River Coho Salmon ESU (<i>O. tshawytscha</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Southern Resident Killer Whale DPS (<i>Orcinus orca</i>)	E	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Green Sturgeon Southern DPS (<i>Acipenser medirostris</i>)	T	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Eulachon Southern DPS (<i>Thaleichthys pacificus</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect

T = Threatened
E = Endangered

Table 4-2. Determination of effects from the Proposed Action on ESA-listed species and designated critical habitat under USFWS jurisdiction

ESA-listed Species	ESA Status	Determination for Species	Determination for Critical Habitat
Columbian white-tailed deer (<i>Odocoileus virginianus leucurus</i>)	T	May Affect, Not Likely to Adversely Affect	No Designated Critical Habitat
Grizzly bear (<i>Ursus arctos horribilis</i>)	T	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Ute ladies'-tresses (<i>Spiranthes diluvialis</i>)	T	May Affect, Not Likely to Adversely Affect	No Designated Critical Habitat
Kootenai River white sturgeon (<i>Acipenser transmontanus</i>)	E	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Bull trout (<i>Salvelinus confluentus</i>)	T	May Affect, Likely to Adversely Affect	May Affect, Likely to Adversely Affect
Yellow-billed Cuckoo (<i>Coccyzus americanus</i>)	Proposed - T	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect
Streaked horned lark (<i>Eremophila alpestris strigata</i>)	T	May Affect, Not Likely to Adversely Affect	May Affect, Not Likely to Adversely Affect

T-Threatened
E-Endangered

4.2 SYNTHESIS OF EFFECTS

The Action Agencies utilized a qualitative approach based on the best available scientific information to determine the effects of the Proposed Action on 16 ESA-listed species regulated by the NMFS and an additional eight ESA-listed species regulated by the USFWS. These species are from across the Columbia River Basin. For the anadromous salmon and steelhead species, effects of the Proposed Action were considered in the aggregate with the baseline condition and cumulative effects for each of 11 factors that were identified as representative of effects to these species, regardless of the source of those effects. Then, the Action Agencies compared the effects of the Proposed Action to the baseline condition and identified as positive, negative, no changes, or not applicable. The summary tables for each of the anadromous 13 ESUs/DPSs from Chapter 3 are synthesized in Table 4-3. The ocean rearing stage was not included in Table 4-3 because 9 of 11 factors were not applicable.

Table 4-3. Synthesis of effects of the Proposed Action on the 13 NMFS ESUs/DPSs, organized by life stage

Factor	SR fall Ch	SR sock	SRB steel	SR sp/su Ch	UCR steel	UCR sp Ch	MCR steel	LCR coho	LCR Ch	LCR steel	LCR chum	UWR Ch	UWR steel	SR fall Ch	SR sock	SRB steel	SR sp/su Ch	UCR steel	UCR sp Ch	MCR steel	LCR coho	LCR Ch	LCR steel	LCR chum	UWR Ch	UWR steel	
	Freshwater Adult Spawning and Juvenile Rearing Sites													Juvenile Salmonid Downstream Migration through CRS													
Survival	Habitat actions in the tributaries should increase survival.													* ** * ** *													
Travel time	No change													Travel time will slightly decrease with the Flex Spill plan.													
Phs prop. (juv)	n/a													Flex Spill plan is expected to slightly increase non-turbine passage.													
TDG	n/a													Spilling to revised gas cap is expected to have negligible negative effect.												n/a	
Temperature	Potential positive effect from continued tributary habitat restoration.													No change													
Turbidity	Potential positive effect from continued tributary habitat restoration.													No change													
Dam passage (adults)	n/a													n/a													
Predation rates	n/a													Continuation of predator management programs should decrease predation.													
Hatcheries	No change													No change													
Predation monitoring	n/a													No change													
Fish status and trend mon.	No change													No change													
	Juvenile Salmonid Estuary Migration and Rearing													Adult Salmonid Migration to Bonneville Dam													
Survival	Continuation of the predator management and habitat restoration actions are expected to slightly increase survival.													Continuation of predator management actions are expected to decrease predation by pinnipeds.													
Travel time	No change													No change													
Phs prop.(juv)	n/a													n/a													
Total dissolved gas	Minor increase in TDG levels to about 35 miles downstream from Bonn.						No change							Minor increase in TDG levels to about 35 miles downstream from Bonneville Dam						No change							
Temperature	No change													No change													
Turbidity	No change													No change													
Dam passage (adults)	n/a													n/a													
Predation rates	Continuation of predator management actions are expected to slightly reduce predation rates.													Continuation of predator management actions are expected to decrease predation by pinnipeds.													
Hatcheries	n/a													n/a													
Predation monitoring	No change													No change													
Fish status and trend mon.	No change													No change													
	Adult Salmonid Migration through CRS Dams													Adult Salmonid Migration Upstream of the CRS													
Survival	No change											n/a	No change											n/a			
Travel time	No change											n/a	No change											n/a			
Phs prop (juv)	n/a													n/a													
TDG	Minor increase in TDG levels.											n/a	No change											n/a			
Temperature	DWK releases		No change											n/a	Existing and future habitat improvements may improve tributary water temperatures.												n/a
Turbidity	No change											n/a	Existing and future habitat improvements may improve tributary turbidity levels.												n/a		
Dam passage (adults)	Monitoring adult migration may assist in development of actions to reduce overshoot.											n/a	n/a														
Predation rates	n/a													n/a													
Hatcheries	No change											n/a	No change											n/a			
Predation monitoring	No change											n/a	n/a														
Fish status and trend mon.	No change											n/a	No change											n/a			

* Flexible spill plan is expected to slightly increase non-turbine passage, and therefore survival.

**For SRB and UCR steelhead, COMPASS modeling showed a slight decrease in survival.

For the USFWS species, their life histories are different enough than the NMFS anadromous species that such a synthesis table was not warranted. The summary of effects for these species can be found at the end of their respective Chapter 3 effects analyses.

As conveyed in the summary tables in Chapter 3 for each ESU/DPS, the individual actions that make up the Proposed Action can result in mixed impacts to the ESU/DPS depending on the life stage. Overall, however, the Proposed Action continues to take positive steps toward improving conditions and reducing impacts on ESA-listed species and associated designated critical habitat. The **spring juvenile fish passage spill operation** is expected to have a moderately positive to slightly negative impact depending on ESU and DPS and life stage. The increased levels of spring spill included in the Proposed Action are based on the predictions of the CSS model that support the conclusion that higher SARs will result from increased spill due to the diversion of juvenile fish from powerhouse and JBS passage to spillway passage. The reduction in powerhouse encounters during the juvenile life stage is hypothesized to reduce the overall scope of latent mortality and to result in a substantial improvement in returning adults, especially for Snake River species that migrate in the spring.

Alternatively, **spring juvenile fish passage spill operation** could result in some negative effects due to the biological uncertainties of exposure to elevated Total Dissolved Gas (TDG) levels during juvenile and adult migrations through the CRS and potential delay of adult upstream migration at some projects. Increased incidence of adult fish falling back over spillways would also be expected with the higher spill levels. Monitoring and an adaptive implementation framework will be in place to help the Action Agencies identify and quickly remedy any of the potential negative effects noted above to anadromous and resident species. Additionally, increased levels of spill are generally associated with lower transport rates as juvenile fish are diverted from bypass routes to the spillway. Past data has shown that transported fish can have higher adult return rates than fish that migrate in river, depending on species and time of year. This relationship is especially relevant for SR steelhead. However, it is expected that the proposed early start of transport of juvenile fish could offset some of this impact on SR steelhead.

Implementation of **tributary habitat** and **estuary habitat** improvement projects under the Proposed Action as well as the accrual of benefits from past projects will have positive effects during the freshwater adult spawning and juvenile rearing and juvenile and adult migration stages due to improved temperature, turbidity conditions, and availability of forage. The benefits of certain tributary habitat projects are expected for resident ESA-listed species as well. Continued **predation management** programs will have positive effects for all life stages except the freshwater spawning and rearing, and ocean rearing stages, as well as migration of returning adults to the CRS. The structural improvements in the Proposed Action for mainstem Snake and Columbia River Dams are predicted to have a positive impact on both juvenile and adult migration.

Reservoir operations in the Proposed Action will have varying degrees of impact to resident ESA-listed species. The operations at Libby Dam are expected to have both minor adverse effects on resident ESA-listed species due to higher river elevations during the winter and minor beneficial effects due to the changes in reservoir elevation, downstream water temperatures, and restoration of native riparian vegetation. Effects to bull trout at Hungry Horse Dam are expected to be minor beneficial effects due to higher reservoir levels in late summer. ESA-listed and resident prey fish species in Lake Roosevelt above Grand Coulee Dam are expected to experience minor adverse effects because of changes in reservoir levels, but minor beneficial effects due to spawning habitat augmentation. The resident fish in Lake

Roosevelt are an important forage resource for ESA-listed bull trout but it is unknown how these changes will indirectly impact bull trout in this reservoir.

Additional detail on the effects of the Proposed Action on salmon and steelhead relative to the current condition (baseline) have been synthesized by factor (Table 4-3).

5 ASSESSMENT OF EFFECTS ON ESSENTIAL FISH HABITAT DESIGNATED PURSUANT TO THE MAGNUSON-STEVENSON FISHERY CONSERVATION AND MANAGEMENT ACT

5.1 BACKGROUND

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), provides for identification, conservation, and enhancement of Essential Fish Habitat (EFH) for species regulated under a federal fisheries management plan. MSA § 305(b), 16 U.S.C. § 1855(b). Fishery management councils designate EFH; federal agencies consult with NMFS with respect to the effects of their actions; NMFS gives federal agencies recommendations regarding how to conserve EFH and offset the effects of agency actions; and federal agencies must inform NMFS how they will act consistent with NMFS' recommendations and, if not, explain the agency's reasons for not following recommendations.

The MSA consultation on EFH may be part of a consultation pursuant to the Endangered Species Act (ESA). 50 C.F.R. § 600.920(f). Consequently, the Action Agencies are including consultation on EFH as part of their consultation with NMFS under the ESA.

As part of the EFH consultation, an agency should provide an EFH Assessment 50 C.F.R. § 600.920(e). The EFH Assessment may be part of an ESA Biological Assessment. Consistent with this provision, the Action Agencies include this section in their BA as their assessment of effects of the Proposed Action upon EFH.

5.2 DESIGNATION OF EFH

Pursuant to the MSA, the Pacific Fishery Management Council has designated EFH for salmon, groundfish, and coastal pelagic species. For salmon EFH, see Appendix A, as modified by Amendment 18, to the 2014 Pacific Coast Salmon Fishery Management Plan, available at http://www.pcouncil.org/wp-content/uploads/2016/03/FMP-through-A-19_Final.pdf. For groundfish EFH, see Amendments 18 and 19 to the Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery (November 2006), available at <https://www.pcouncil.org/groundfish/fishery-management-plan/>. For coastal pelagic species EFH, see The Fishery Management Plan for Coastal Pelagic Species (December 1998), available at <https://www.pcouncil.org/coastal-pelagic-species/fishery-management-plan-and-amendments/>.

5.3 PROPOSED ACTION

The Action Agencies describe the action area and the Proposed Action in chapters 1 and 2 of this BA.

5.4 EFFECTS OF THE PROPOSED ACTION ON EFH

The Action Agencies provide detailed descriptions of the effects of the Proposed Action on salmonids in the BA (see Chapter 3). These appendices include a discussion of the effects on the Columbia River estuary, which is part of designated EFH for salmon, groundfish, and coastal pelagic species, and areas in the Columbia River occupied by salmonids during portions of their lifecycles. Consequently, the Proposed Action may affect this EFH, and the Action Agencies considered effects of the Proposed Action on these species' EFH.

5.5 EFFECTS ON SALMON EFH

This BA describes effects of CRS management on salmonids.

5.6 EFFECTS ON GROUND FISH AND COASTAL PELAGIC EFH

NMFS has addressed effects of CRS management on groundfish and coastal pelagic EFH in Section 3 of the 2019 NMFS CRS BiOp and stated that the Proposed Action and Incidental Take Statement "includes the best approaches to avoid or minimize those adverse effects." The Action Agencies believe the Proposed Action in this BA does not substantially change in a way that would result in impact to EFH for ground fish that have not already been considered in the 2019 BiOp therefore the analyses are still pertinent and are referred to here instead of repeating much of the same information. See also the Pacific Fishery Management Council's designations of EFH referenced above.

5.7 MITIGATION

The Action Agencies plan to implement the Proposed Action and conservation measures described in this BA. Taken collectively the Proposed Action and conservation measures avoid or minimized adverse effects of the Proposed Action on EFH for salmon and will also minimize adverse effects of the Proposed Action on groundfish and coastal pelagic EFH. The Proposed Action carries forward many of the reasonable and prudent measures recommended by NMFS in the 2019 NMFS Fisheries CRS BiOp.

**Consultation Package for
Operations and Maintenance of the
Columbia River System**

**APPENDIX A – COLUMBIA RIVER SYSTEM PROJECT AUTHORIZATIONS AND
DESCRIPTIONS**

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

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A.1 U.S. ARMY CORPS OF ENGINEERS STORAGE PROJECTS

A.1.1 General description

The United States Army Corps of Engineers (Corps) operates four storage projects that function as part of the Columbia River System. These four projects are Libby Dam, Dworshak Dam, Albeni Falls Dam, and John Day Dam.¹

Libby Dam is located on the Kootenai River at river mile (RM) 221.9 in Lincoln County in northwestern Montana. The project is about 15 miles northeast of Libby, Montana. Lake Kootenai, Libby Dam's reservoir, is about 90 miles long and extends about 42 miles into Canada. The dam regulates streamflow for 17 downstream hydroelectric projects in the United States and Canada.

Dworshak Dam is located at RM 1.9 on the North Fork Clearwater River, near Ashaka in Clearwater County, Idaho. The Dworshak Project has a watershed of approximately 2,440 square miles and provides flood risk management (FRM) for the Clearwater, Snake, and Columbia River Basins. The reservoir formed by the dam (Dworshak Reservoir) extends 53.6 miles upstream.

Albeni Falls Dam is located at RM 90 on the Pend Oreille River in Bonner County, Idaho, 2.5 miles east of Newport, Washington, and 50 miles northeast of Spokane, Washington. Lake Pend Oreille is a natural lake, 68 miles long and one of the largest and deepest lakes in the western United States. Albeni Falls Dam impounds and regulates the top 11.5 feet of the lake, as well as approximately 25 miles of the Pend Oreille River between the lake and the dam.

John Day Dam is a multipurpose project located in northeastern Oregon and southeastern Washington, at RM 215.6 of the Columbia River. Lake Umatilla, John Day Dam's reservoir, extends approximately 76 miles upstream of John Day Dam and is the second largest reservoir in the Columbia River. Unlike other dams in the lower Columbia River (LCR), John Day is operated for FRM (in addition to the other authorized purposes of navigation, irrigation, recreation, fish and wildlife conservation, and hydropower generation). When high runoff is forecast, Lake Umatilla is lowered to provide space for control of about 500,000 acre-feet of floodwaters.

A.1.2 Authorization and project purposes

Construction of the Libby Dam project is authorized by the Flood Control Act of 1950 (Pub. L. No. 81-516, 81st Congress, 2nd Session) in accordance with a plan set forth in House Document 531, 81st Congress, 2nd Session. Project-authorized purposes include FRM, hydropower, navigation, recreation, and fish and wildlife conservation. Recreation is authorized in the Flood Control Act of 1944, Section 4 (Pub. L. No. 78-534). Fish and Wildlife Conservation is also authorized by the Fish and Wildlife Coordination Act of 1958 (Pub. L. No. 85-624), and the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Pub. L. No. 96-501). Although authorized in 1950, the construction and operation of Libby Dam was authorized by Congress as part of the "Treaty between Canada and the

¹ While John Day Dam is listed as a storage project, the amount of storage is small and the project is operated as a run-of-river project.

United States of America Relating to Cooperative Development of the Water Resources of the Columbia River Basin” in 1964 (The Columbia River Treaty).

Construction of Dworshak Dam was authorized for the purpose of FRM under Pub. L. No. 85-500 and Pub. L. No. 87-874. Additional authorized project purposes under Pub. L. No. 87-874 include hydropower generation, navigation, and fish and wildlife conservation. Recreation is a project purpose under Pub. L. No. 78-534.

Construction of the Albeni Falls multipurpose Dam and powerhouse is authorized by the Flood Control Act of 1950 (Pub. L. No. 81-516, 81st Congress, 2nd Session in accordance with the recommendations of the Chief of Engineers in Senate Doc. 9, 81st Congress, 1st Session). Project authorized purposes include FRM, hydropower, navigation, recreation, and fish and wildlife conservation. Recreation is authorized in the Flood Control Act of 1944, Section 4 (Pub. L. No. 78-534). Fish and wildlife conservation is also authorized by the Fish and Wildlife Coordination Act of 1958 (Pub. L. No. 85-624) and the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Pub. L. No. 96-501).

A.1.3 Description of projects

In addition to fulfilling the above listed authorized purposes, Libby Dam, Dworshak Dam, Albeni Falls Dam, and John Day Dam provide additional specific benefits. Libby Dam provides FRM storage for 17 downstream hydroelectric projects in the United States and Canada. The operation of Albeni Falls Dam primarily benefits FRM of Lake Pend Oreille, power generation, and regulation of streamflow for 15 downstream federal and non-federal hydroelectric projects. Summary information is presented for the three projects in Table A-1.

Table A-1. Corps storage projects summary information

Facility	Type of Facility	Year Completed	River	River Mile	Reservoir Name	Usable Reservoir Capacity (million acre-feet)
Libby	Storage	1977 ^a	Kootenai	221.9	Lake Kooconusa	4.9
Dworshak	Storage	1973	North Fork Clearwater	1.9	Dworshak Reservoir	2.0
Albeni Falls	Storage	1955	Pend Oreille	90	Lake Pend Oreille	1.2
John Day	Storage	1971	Columbia	215.6	Lake Umatilla	0.5

^a FRM operations were initiated in 1972, power generation came online in 1975. Four generators were completed in 1977, with a fifth unit completed in 1984.

A.1.4 Libby Dam

Construction of Libby Dam began in 1966 and FRM operations began in 1973. Power generation came online in 1975, and initial powerhouse construction with four generators (with Francis-type turbines) was completed in 1976. A fifth unit was completed and brought online in 1984. The powerhouse was

built to accept eight units, and the remaining three units are partially installed but were not finished when the planned reregulation dam immediately downstream was determined to not be within the project's authorization.

Libby Dam is a concrete gravity dam with 47 monoliths, a total length of 2,887 feet, and a maximum height of 432 feet from bedrock to the roadway deck at the top of the dam. The elevation of the roadway deck is 2,472 feet elevation above mean sea level.²

The powerhouse contains eight unit bays, with operable units in the five bays closest to the right bank. Each generator unit has a 120-megawatt (MW) capacity. The routine electrical generating capacity at Libby Dam is 600 MW under optimal head conditions.

The turbine units are operated as the primary outlets from the project and contribute to meeting the electrical needs of the region. Depending on river flows and limited project operating constraints, which include protections for resident fish, turbine operations can be varied to more closely match energy demand. Peak generation typically occurs coincident with the November–December draft of the reservoir and in May–June during the release of water for Kootenai River white sturgeon. Additionally, generation may increase during cold-snap periods in January and February if sufficient reservoir volume is available. Normally, all turbine units are made available for spring operations to pass high flows and winter periods when very cold weather may result in emergency generation requirements. When not operating to minimum flows, hydropower operations will operate to achieve a 75 percent chance of reaching the April 10 objective elevation to increase flows for spring flow management.

Transmission limitations in the Flathead Valley can, under certain conditions, require Libby Dam to either reduce or increase generation. The Bonneville Power Administration (Bonneville) has implemented transmission system protection measures to minimize the occurrence of modifications to generation at Libby Dam. These limitations are required to maintain reliability of the power system to within required standards. The limits are also a function of the amount of energy that is consumed in the Flathead Valley. During periods when high outflows from Libby Dam are required and the amount of energy consumed in the Flathead Valley is low, the current combined generation limit of 920 MW for Libby Dam and Hungry Horse Dam may be reduced until the condition is alleviated.

A multiple-bulkhead intake system permits selective withdrawal of water from the reservoir above elevation 2,222 feet. The selective withdrawal system helps regulate water temperature of powerhouse releases. The system consists of a concrete housing for bulkheads and guides attached to the upstream side of the dam over the penstock intakes. Each guide accommodates up to 22 10-foot-high steel bulkheads, which allows withdrawal of water from the reservoir as high as elevation 2,442 feet. Bulkheads are placed or removed manually using a crane hoist in response to temperature release requirements and reservoir forebay levels.

The dam includes a spillway with two bays and two spillway Tainter gates; the spillway crest elevation is 2,405 feet. A sluice outlet system includes three sluices individually regulated by separate Tainter gates. The sluices have an intake invert (bottom elevation) at elevation 2,201.5 feet and empty into the spillway stilling basin. The stilling basin is a conventional hydraulic-jump type that provides energy dissipation for both sluice and spillway flow. The stilling basin is defined by training walls leading from

² All elevations in this document are relative to mean sea level unless stated otherwise.

the spillway and has a width of 116 feet, a length of 275 feet, and a floor elevation of 2,073 feet. Spill may be necessary in circumstances during which river flows exceed powerhouse hydraulic capacity, due to equipment malfunction or modeling and forecasting uncertainties, or for other purposes, such as ensuring power and transmission system stability, passing debris, or FRM in spring. Spill could involve use of the sluiceway.

Lake Koocanusa, Libby Dam's reservoir, is about 90 miles long and extends about 42 miles into Canada at full pool. Normal full pool and minimum reservoir elevations are 2,459 feet and 2,287 feet, respectively. The maximum water surface elevation of Lake Koocanusa is the normal full pool elevation of 2,459 feet. Under extreme or emergency situations, Lake Koocanusa may be filled up to elevation 2,461 feet. Lake Koocanusa has 4.9 million acre-feet of usable storage for FRM. At full pool, the reservoir area is 46,456 acres (about 62 percent of the reservoir acreage is in the United States).

The majority of public recreation facilities associated with the Libby Dam Project are administered by the U.S. Forest Service (USFS) under a Memorandum of Agreement. The Corps and USFS operate and maintain 11 campgrounds and 13 boat launches on the U.S. side of the lake. The Corps administers the recreation area on Lake Koocanusa by Libby Dam, as well as some small recreation areas downstream from the dam on the Kootenai River. The Canadian portion of Lake Koocanusa is administered by British Columbia Parks; the British Columbia Ministry of Forests, Lands and Natural Resource Operations; and private Canadian citizens.

The Libby Dam Project also includes the Murray Springs Fish Hatchery, built in 1978, which mitigates project-related fishery losses in the Kootenai River. Montana Fish, Wildlife and Parks operates and maintains the hatchery under Cooperative Agreement and funding by the Corps. Montana Fish, Wildlife and Parks stocks fish from the hatchery into the reservoir, closed-basin lakes, or elsewhere in the state.

A.1.5 Dworshak Dam and Reservoir

The Dworshak Project was placed into service in March 1973. It has a watershed of approximately 2,440 square miles and provides FRM for the Snake and Columbia River Basins. The hydraulic height of the dam is 632 feet at full pool. The dam has a crest length of 3,287 feet, and a maximum base width of 574 feet. The spillway is located on the left side of the dam, extends down the front of the dam, and consists of a concrete chute with two Tainter gates. Two low-level regulating outlets provide spill discharge at lower lake levels. The reservoir elevations range from 1,600 feet at full pool to 1,445 feet at minimum pool elevation.

Dworshak Dam is equipped with a water intake structure that has selector gates for selective withdrawal of water from various levels of the lake to provide temperature control of released water through the turbines. The powerhouse encloses two 90 MW generating units and one 220 MW generating unit. Vacant generator spaces and penstocks adjacent to the powerhouse are provided for the possible installation of three additional generating units.

Dworshak Reservoir extends 53.6 miles upstream to RM 55.5 when the reservoir is at full pool at elevation 1,600 feet. The water surface area is 16,417 acres at full pool elevation of 1,600 feet and 9,050 at minimum pool elevation of 1,445. The reservoir has a shoreline length of 175 miles at full pool. When full, the reservoir contains 3.453 million acre-feet (MAF) of water. The difference between full and minimum operating pool levels provides 2 MAF of usable water storage for FRM and/or power

generation. Authorized and operating purposes for Dworshak include FRM, hydropower, navigation, recreation, and fish and wildlife conservation.

There are no fish-passage facilities at Dworshak Dam, and migrations of anadromous fish are blocked by the dam. The Dworshak National Fish Hatchery was constructed as mitigation for the dam and is located downstream of the dam on the left bank, at the confluence of the North Fork Clearwater River and the Clearwater River. The primary water supply for the hatchery is provided by pumps on the North Fork Clearwater River, and water temperatures for the hatchery are set by using the selector gates on the turbine intakes to control the temperature of water released from the dam. During time intervals when excess reservoir water is available at adjacent Clearwater Hatchery, that water is used to rear steelhead in order to minimize exposure to the infectious hematopoietic necrosis virus.

There are 29,318 acres of fee-owned project lands surrounding Dworshak Reservoir. The majority of the Corps-managed lands are used for public recreation, wildlife habitat, wildlife mitigation, and project structures. There are 14 developed recreation areas and 121 boat access mini-camps around Dworshak Reservoir. Two camping areas are licensed to the Idaho Department of Parks and Recreation and are operated as Dworshak State Park. A total of 5,033 acres are managed for mitigation for elk wintering habitat and an additional 4,541 acres are managed specifically for wildlife. Other project acreages are managed under environmental stewardship principles for wildlife habitat and other environmental concerns.

A.1.6 Albeni Falls Dam

Albeni Falls Dam is constructed on the granite rock outcropping that formed the original Albeni Falls. The dam and spillway are embedded and tied into the granite rock, and the surface rock was cut and shaped to increase conveyance and provide an improved natural tailrace for the spillway and powerhouse discharge.

Construction of Albeni Falls Dam began in 1951 and the final unit was placed in operation in 1955. Usable water storage was available in 1952. Authorized purposes include FRM, hydropower, navigation, recreation, and fish and wildlife conservation. Albeni Falls Dam is a concrete gravity, gate-controlled structure with a submerged spillway 472 feet long, and a net opening of 400 feet. The overall length, including the non-overflow abutment section, is 755 feet. The height is 90 feet, with a crest elevation of 2,033 feet. The elevation at the top of the gates is 2,065 feet, while the elevation at the top of the operating deck is 2,097 feet. The spillway has ten roller-chain, two-leaf, vertical-lift gates, each 40 feet wide and 32 feet high.

The powerhouse is 206 feet wide and 301 feet long, with three Kaplan turbines, each with a rated capacity of 19,600 horsepower at 22-foot head. Total power plant rated nameplate capacity is 42.6 MW, with an annual production of approximately 200,000 MW-hours. In case of a commercial power outage, a 350-kilowatt diesel-electric generator provides emergency power for operating the spillway crane, operation of pumps to prevent flooding in the powerhouse, and other critical loads.

Albeni Falls Dam powerhouse hydraulic capacity ranges from 900 cubic feet per second (CFS) with one unit at speed-no-load, up to the maximum powerhouse capacity of 35,000 CFS. Except during freeflow conditions, the powerhouse discharge is the primary outlet used to maintain the lake elevations, discharge, and rate-of-change requirements. During periods when outflow is between 50,000 and

70,000 CFS, depending on the lake elevation, the river stage downstream of the dam reduces power plant hydraulic head below eight feet, the minimum head for power generation. The powerhouse generation is then curtailed, and the spillway is operated in a freeflow condition until streamflows subside enough to provide sufficient head at the powerhouse.

Powerhouse generation is normally scheduled by the Albeni Falls Dam powerhouse operator based on actual or coordinated outflow conditions. The powerhouse status is reported hourly to Bonneville. Peak generation at the project occurs during the FRM draft October through November and before and after the freeflow operations.

In case of emergency or power plant outage, Albeni Falls Dam discharge may be reduced below 4,000 CFS. If conditions indicate the discharge will remain below 4,000 CFS beyond one hour, Albeni Falls Dam must immediately notify the Corps' Northwestern Division Reservoir Control Center, Bonneville, Seattle City Light, Box Canyon Dam, and the Pend Oreille Public Utility District, and increase discharge above 4,000 CFS as quickly as possible, using spillway releases if necessary.

The spillway structure contains ten bays and ten roller train, vertical-lift, span-type gates. Each gate has an upper and lower leaf that are latched together for normal operation. The spillway crest elevation is 2,033 feet. The spillway is operated to pass flow above the available turbine capacity. Additionally, during high flows, the downstream river stage increases, reducing the net hydraulic head at the project such that there is insufficient head to operate the powerhouse. At this point, the outflow from the project transitions to a freeflow condition in which the spillway gates are raised above the water surface, allowing the river to freeflow through the project. This condition can occur at flows at a range of 50,000 CFS to 70,000 CFS, depending on the lake elevation. Outflow from the lake during freeflow conditions is controlled by the hydraulic conveyance capacity of the Pend Oreille River between the Lake and the Albeni Falls Dam. There are no sluiceways.

The Corps has real estate interests in approximately 18,627 acres surrounding Lake Pend Oreille, of which approximately 14,390 acres are in the form of flowage easements and withdrawn lands from other federal agencies. The remaining 4,237 acres are held in fee for authorized purposes, including recreation, project operations, and wildlife conservation (approximately 4,000 acres are in conservation easements).

A.1.7 John Day Dam

A detailed description of the John Day Lock and Dam project is provided in Section A.5 (U.S. Army Corps of Engineers Lower Columbia River Dams).

A.2 U.S. BUREAU OF RECLAMATION STORAGE PROJECTS

A.2.1 General description

The Bureau of Reclamation (Reclamation) operates two projects that function as part of the Columbia River System (CRS). Reclamation's two projects in the CRS are the Columbia Basin Project and the Hungry Horse Project.

The Columbia Basin Project (CBP) is a multipurpose development on the upper Columbia River in central Washington. The major facilities of the CBP that are included in this consultation are Grand Coulee Dam and its impoundment (Lake Roosevelt), the Grand Coulee Powerplant complex that includes the John W. Keys III Pump/Generating Plant (JWKIII), and Banks Lake.

The Hungry Horse Project, on the South Fork of the Flathead River in northwestern Montana, is operated primarily for FRM and power generation as part of the CRS. The dam is situated in a deep, narrow canyon, approximately five miles southeast of the South Fork’s confluence with the mainstem Flathead River. The project includes a dam, reservoir, power plant, and switchyard.

A.2.2 Authorization

Congress authorized Reclamation to operate Grand Coulee Dam for the multiple purposes of FRM, navigation, generation of electricity, storage and delivery of water for irrigation, and other beneficial uses.

The authorized purposes of the Hungry Horse Project are irrigation, FRM, navigation, streamflow regulation, hydroelectric generation, and other beneficial uses including fish and wildlife conservation. The project’s irrigation component has not yet been developed.

Table A-2. Columbia Basin Project and Hungry Horse Project authorizations

Feature	Authorization
Construction of Grand Coulee Dam	Congress allocated funds under National Industrial Recovery Act of June 16, 1933
Columbia Basin Project	Public Law 74-409 on August 30, 1935 Reauthorized Public Law 78-8 to bring provisions under the Reclamation Project Act of 1939
Units 7, 8, and 9 of Right Power Plant	Approved by the Secretary on January 5, 1949
Third Power Plant	Public Law 89-448 on June 14, 1966, and Public Law 89-561 on September 7, 1966
Construction of Hungry Horse	Public Law 78-329 on June 5, 1944

The projects described here are authorized, funded, or carried out by Reclamation by virtue of Congressional or Secretarial authorizations, Congressional appropriations, and contracts with Reclamation. Reclamation received authorization for each of its projects from either Congress or the Secretary of the Interior, who has authority under the 1902 Reclamation Act to approve construction after a finding of feasibility. The Congressional and Secretarial authorizations state the purposes to be served by each project. Congress has directed in the Reclamation laws that Reclamation enter into contracts with project water users. These contracts set out, among other things, Reclamation’s obligations to store and deliver project water to irrigation districts, municipalities, and other entities. Additionally, the 1902 Reclamation Act requires that Reclamation comply with state law with regard to control, appropriation, use, and distribution of waters. Water can be stored and delivered by a project

only for authorized purposes for which Reclamation has asserted or obtained a state water right in accordance with Section 8 of the Reclamation Act of 1902 and applicable federal law. Reclamation must honor senior or prior water rights in storing and diverting project water. Conversely, project water is protected by state watermasters from diversion by junior appropriators. The active cooperation of the state water rights administrators is essential in ensuring that any water Reclamation delivers for flow augmentation or any other purpose reaches the targeted points of delivery.

A.2.3 Authorized purposes and description of projects

Grand Coulee Dam, the primary storage and diversion structure for the Columbia Basin Project, was constructed from 1933 to 1941 and modified from 1967 to 1974 and 1982 to 1988. Hydroelectric generating units were installed to supply electric power for the war effort. After the war, construction centered on the associated pumping plant and irrigation facilities.

In 1952, the Grand Coulee Pumping Plant (now called John W. Keys III Pump/Generating Plant, or JWKIII) began delivering irrigation water to about 66,000 acres. The original plans anticipated about 1.1 million irrigated acres. These lands produce potatoes, sweet corn, onions, seed and other specialty crops, grapes, fruit, dry beans, grain, alfalfa hay, and ensilage crops.

The Grand Coulee Dam Powerplant complex consists of three powerhouses with 24 generating units (six in the Third Powerplant [TPP], and 18 in the Left and Right Powerplants) with a total generating capacity of around 7,000 MW, there are an additional six pump generators in the JWKIII PGP (at about 50 MW each), and if including the station service units there would a total of 33 generating units. The average annual generation of the Grand Coulee Powerplants is about 20 billion kilowatt-hours, which is a large share of the power requirements for the Northwest. The third power plant alone can produce enough energy to meet the needs of Portland, Oregon, and Seattle, Washington.

Hungry Horse Dam and Powerplant were constructed between 1948 and 1953. The dam creates a large reservoir by storing water in times of heavy runoff to minimize downstream flooding. This stored water is released for power generation and flow augmentation when the natural flow of the river is low. These releases increase generation at Hungry Horse Dam during otherwise lower flow periods, additionally the operations of Hungry Horse Dam creates downstream power benefits by also increasing flows through downstream projects, which include seven federal projects and an additional 13 non-federal hydropower projects.

The Hungry Horse Powerplant consists of four 107 MW generators with a total installed capacity of 428 MW. However, current transmission limitations in Northwest Montana restrict generation to 310 MW.

Summary information is presented for the two projects in Table A-3.

Table A-3. Reclamation storage projects summary information

Facility	Type of Facility	Year Completed	River	River Mile	Reservoir Name	Total Reservoir Capacity (million acre-feet)
Grand Coulee	Storage	1941 ^a	Columbia	596.6	Franklin D. Roosevelt Lake (Lake Roosevelt)	9.7 ^b
Hungry Horse	Storage	1953	South Fork of the Flathead River	5	Hungry Horse Reservoir	3.46

^a Grand Coulee Dam was constructed from 1933 to 1941 and modified from 1967 to 1974 and 1982 to 1988.

^b This total includes active and inactive space in Lake Roosevelt (with approximately 5.4 million acre-feet active space). Banks Lake has an additional 0.7 million acre-feet of storage. Water is pumped from Lake Roosevelt to Banks Lake for irrigation delivery and then diverted from Banks Lake.

A.2.3.1 Columbia Basin Project

Grand Coulee Dam is the primary storage and diversion structure for the Columbia Basin Project. The dam, one of the largest concrete structures ever constructed, is 550 feet high and 5,673 feet long. The dam was constructed from 1933 to 1941 and was modified from 1967 to 1975 by constructing a 1,170-foot-long and 210-foot-high forebay dam along the right abutment as part of the construction for the TPP. The lake elevation is 1,208 feet at minimum pool and 1,290 feet at full pool.³ Lake Roosevelt has a total storage capacity of 9.7 million acre-feet (5.35 million acre-feet of active space) and extends more than 151 miles upstream to the Canadian border. Reclamation operates Grand Coulee Dam in coordination with other projects in the Columbia River Basin to provide system FRM space in Lake Roosevelt to help manage flow of the Columbia River at The Dalles Dam.

The Grand Coulee Powerplant complex consists of power plants on the right and left sides of the spillway and the TPP on the right bank of the dam, plus six pump-/generators in the JWKIII, with a total of 33 generating units. The right and left power plants have a total of 18 units of 125 MW capacity plus three station service units of ten MW capacity, for a total capacity of 2,280 MW. The TPP contains three units of 690 MW capacity and three units of 805 MW capacity.

The JWKIII on the left bank was designed to accommodate 12 pumping units to pump water from Lake Roosevelt to Banks Lake for irrigation delivery. Pump capacity is dependent upon pool elevations in Lake Roosevelt and Banks Lake. Generally, the six pumps, each with an approximate capacity of 1,600 CFS, were installed by 1951, two pump/generators with a pumping capacity of 1,605 CFS each and a generating capacity of 50 MW were installed in 1973, and four pump/generators units with a pumping capacity of 1,700 CFS each and a generating capacity of 53.5 MW were installed between 1983 and 1994. The pumping/generating plant lifts water to the 1.6-mile-long feeder canal that leads to Banks Lake. When Lake Roosevelt is below 1,240 feet, the elevation (or head) exceeds the ability of the

³ All elevations are reported in NGVD29 in this appendix.

pump-generators to pump. When this occurs, the plant may not be able to meet the full irrigation demand and Banks Lake may be drafted to meet these demands.

Banks Lake, located in an old ice-age channel called the Grand Coulee, is a re-regulating reservoir. This 27-mile-long reservoir is formed by the North Dam, which is located about two miles southwest of Grand Coulee Dam, and the Dry Falls Dam, which is located about 29 miles south of Grand Coulee Dam. Banks Lake has an active storage capacity of 715,000 acre-feet, feeds water to the Columbia Basin Project through the Main Canal at Dry Falls Dam and provides water to operate the pump/generators in generation mode at JWKIII.

The irrigation season extends from about mid-March to November 1. More detail on depletions from the Columbia River for the Columbia Basin Project can be found in Appendix C.

A.2.3.2 Hungry Horse Dam

Facilities at the Hungry Horse Project include the dam, reservoir, and power plant. The 564-foot-high dam is a variable-thickness concrete arch structure with a 2,115-foot crest. Hungry Horse Dam has three ways to discharge water from the project; the power plant, the hollow jet valves, and the ring gate (“glory hole spillway”). There are three hollow jet valves with a combined capacity of 13,980 CFS at elevation 3,560 feet and a glory hole spillway⁴ with a capacity of 50,000 CFS at elevation 3,565 feet. The total storage capacity of the reservoir is 3.5 million acre-feet.

The Hungry Horse Powerplant originally included four 71.25 MW generators (a total of 285 MW installed capacity). The capacity of the generators was up-rated to 107 MW each in the 1990s, which increased the installed capacity from 285 MW to 428 MW. However, current transmission limitations restrict generation to around 310 MW. The hydraulic capacity of the power plant is about 12,000 CFS if generating at full capacity (428 MW), but with current transmission limitations (310 MW) the hydraulic capacity of the power plant is limited to a maximum approaching 9,000 CFS. Total discharge capacity at elevation 3,560 feet, with current transmission limitations, is 54,680 CFS (9,000 CFS through three generating units, 13,680 CFS through the three hollow jet valve, and 32,000 CFS through the Ring Gate).

A.2.4 Project activities

A.2.4.1 Columbia Basin Project

OPERATION AND MAINTENANCE

Reclamation operates and maintains the Columbia Basin Project’s major facilities. The Quincy-Columbia Basin Irrigation District, East Columbia Basin Irrigation District, and South Columbia Basin Irrigation District operate and maintain the irrigation distribution facilities within their geographic areas.

Operations for the Columbia Basin Project included in the consultation:

- Storage and release of water from Lake Roosevelt and Banks Lake

⁴ Characterized by an intake that functions like a standpipe in the reservoir forebay.

- Diversion of water at the JWKIII pump/generating plant
- Power generation, transmission, and marketing (by Bonneville) at the Grand Coulee Left, Right, and Third Powerplants and the JWKIII
- Maintenance of project facilities at Grand coulee Dam, JKWIII, and Banks Lake.

The section below on Grand Coulee Dam’s multipurpose operations more fully describe the operations of Grand Coulee Dam and its associated facilities. Aside from operations of Grand Coulee Dam and flow augmentation from Banks Lake, Reclamation does not further coordinate the operation of the Columbia Basin Project with the CRS.

GRAND COULEE DAM MULTI-PURPOSE OPERATIONS

Congress has authorized Reclamation to operate Grand Coulee Dam for the multiple purposes of FRM, navigation, generation of electricity, storage and delivery of water for irrigation, and other beneficial uses, including fish and wildlife conservation. Reclamation also operates the dam in coordination with the Mid-Columbia Public Utility District projects and other CRS facilities. Not only does Grand Coulee Dam’s operation reflect multiple factors, such as water supply conditions, hydroelectric power generation requirements, and flow needs for fish, but the specific operating purposes also change from month to month and season to season. Reclamation seeks to balance the needs of the multiple purposes. This section discusses the general operating scheme for the project, by month and season.

Fall Operations: September–December

In the fall, Reclamation then operates Grand Coulee Dam to provide augmentation flows for fish, support minimum flows downstream of Bonneville Dam, and meet hydropower operational targets for these months as necessary. Reclamation will attempt to refill Lake Roosevelt to a minimum elevation of 1,283 feet by the end of September and no later than the end of October, or as coordinated in-season with the tribes and Bonneville Power Administration (Bonneville). Reclamation will have attempted to refill Lake Roosevelt to elevation 1,283 feet or higher to support resident fish, including access to shoreline and tributary habitat. In some years, refilling to 1,283 feet elevation may be delayed to support power operation flexibility—this typically would occur in dry years.

Reclamation limits any drafts for power to elevation 1,275 feet in November and elevation 1,270 feet in December. Fall operations also support spawning and incubation flows for LCR chum salmon and also spawning and protection flows for Hanford Reach fall Chinook salmon when possible.

Winter Operations: January–March

During the winter season, Reclamation’s operating priorities are FRM, minimum flows for fish and power operations. Reclamation generally drafts Lake Roosevelt below the required FRM elevations to generate power. The draft of Lake Roosevelt can help provide protection flows for Hanford Reach fall Chinook salmon redds, and for chum redds below Bonneville Dam. The Corps has established the Lake Roosevelt storage reservation diagrams (SRDs), which include space requirements at Lake Roosevelt that are determined from the runoff forecast for The Dalles minus the system FRM space available upstream of The Dalles other than at Lake Roosevelt.

During these three months, Reclamation releases water while maintaining the reservoir elevation at or above the Variable Draft Limit (VDL).⁵ The VDL is set based on an assumed inflow volume that has an 85 percent probability of occurrence while still providing the required flows at Vernita Bar for salmon. The VDL is calculated each month after the official water supply forecasts and FRM elevations are issued. This winter power flexibility is an important tool that is used to balance the winter power demands in the Northwest and fish flows as demonstrated by the spring elevation objective on April 10.⁶

Spring Operations: April–June

During the spring season, most of Grand Coulee Dam’s authorized purposes come into play as Reclamation operates the facilities for FRM, spring flow augmentation for fish, irrigation storage and delivery, and power generation. During early and mid-spring, Reclamation operates Grand Coulee Dam primarily for FRM, flow augmentation for juvenile salmon and steelhead migration, and power generation. Irrigation withdrawals for the Columbia Basin Project typically begin in late March but pumping from Lake Roosevelt to Banks Lake is relatively light (less than summer demand) until April. On April 30, Lake Roosevelt is typically at its lowest elevation to maintain adequate space to capture high flows to reduce downstream flooding. The reservoir’s minimum pool is at elevation 1,208 feet.

The Inchelium Ferry, an important transportation connection for medical services and local schools, is inoperable below 1,229 feet. FRM space requirements caused the ferry to be inoperable 39 days in 1997, 33 days in 1999, and 34 days in 2011, 7 days in 2012, and 3 days in 2014; power emergencies which resulted in a deep reservoir draft caused the ferry to go out in 2001 year for 60 days.

As spring flow increases, Reclamation captures some of this flow to help refill the reservoir and releases flow to provide flow augmentation to help juvenile salmon and steelhead travel downstream. From April 30 through the end of May, Reclamation may continue to draft Lake Roosevelt below the April 30 FRM elevation to support flow objectives at Priest Rapids Dam and McNary Dam. This additional draft below the April 30 FRM elevation to support flow objectives typically will occur in drier years to augment low streamflows and is an operation that is coordinated with the TMT ([Technical Management Team], a regional coordination group comprised of federal agencies and non-federal sovereigns).

Reclamation pumps water from the Lake Roosevelt forebay to Banks Lake through six pumps and six pump/generators to supply the project’s irrigation water. Irrigation demand is met through a combination of pumping and operations of Banks Lake.

⁵ A VDL is a computed end-of-month elevation limit for drafting Grand Coulee Dam for the periods January, February, and March. The VDLs are used to provide winter power flexibility while maintaining an 85 percent probability of achieving refill of the project to its 2014 NMFS biological opinion (BiOp) elevation objective for April 10 (see April 10 URC definition). The VDLs have lower limits that are set at elevations 1260 feet for January, 1250 feet for February, and 1240 feet for March. The basic computation assumes an inflow that has an 85 percent probability of occurrence from which the volume needed to meet minimum flows at Vernita Bar is subtracted. The remainder is the volume available for winter power flexibility.

⁶ The April 10 elevation is based on water supply forecasts and end of March and April 15 FRM elevations.

The reservoir is typically refilled after the Fourth of July holiday. In order to demonstrate that water was released from Lake Roosevelt during the spring under the Lake Roosevelt Incremental Storage Release Project (LRISRP), Reclamation will target a refill elevation following a recommendation from the Fish Flow Release Advisory Group (FFRAG).⁷ The FFRAG provides a mechanism for the State of Washington and fish-managers to provide input on the shape of the LRISRP instream flow water release. The water delivery contemplated in this Proposed Action is up to 3.4 MAF annually—this includes the additional 45 kaf that is a new part of this Proposed Action (Appendix C). Spring flow impacts attributed to the diversion of the additional 45kaf would be mitigated by missing refill by up to 0.25 feet to reflect the portion of the additional 45kaf delivered in the spring period, when this additional supply is developed.

In the spring, often during refill in wetter years, Grand Coulee Dam must spill flows to meet FRM objectives; spill occurs when the project must release more outflow than the capacity allows through the power plants. Although there are no flow restrictions at Grand Coulee Dam to reduce gas levels, there are priorities for how the water is released when spill is necessary. The purpose of the actions below is to reduce total dissolved gas (TDG) that could harm resident fish below Grand Coulee Dam and anadromous fish downstream of Chief Joseph Dam:

- If the water elevation is above 1,265.5 feet, Reclamation releases the water evenly across the 11 spillway drum gates, which produces significantly lower TDG than spilling water through the outlet tubes.
- If the water surface elevation is below elevation 1,265.5 feet, Grand Coulee Dam is moved down on the regional spill priority list.
- If water is to be released through the outlets, then it is released evenly through the upper and lower gates. If only two gates are required, then an upper gate and the lower gate immediately below will be used (and not two side-by-side gates).

Summer Operations: July–August

During the summer season, Reclamation’s operating priorities are irrigation, flow augmentation for fish, and power generation. In July and August, Reclamation continues to supply irrigation water to Banks Lake for the Columbia Basin Project. In August, Reclamation will reduce pumping to Banks Lake and allow the reservoir to draft five feet to elevation 1,265 feet; this operation, in combination with the end-of August draft of Lake Roosevelt, is to provide summer flow augmentation for fish.

Reclamation will draft Lake Roosevelt to as low as elevation 1,278 feet to support McNary Dam salmon flow objectives. If the July final forecasted (as defined in the Water Management Plan) runoff volume for the April through August period at The Dalles Dam is less than April–August 30-year average volume

⁷ LRISRP identified up to 1.8 feet of Lake Roosevelt’s elevation to supply water for municipal and industrial use, streamflow enhancement, and as an alternative source to irrigators and others pumping from the Odessa aquifer and interruptables along the Columbia River. FFRAG has worked to develop a framework for shaping LRISRP instream flow augmentation for the benefit of anadromous species from April through August. Members of the FFRAG include the Confederated Tribes of the Colville Reservation, the Yakama Nation, the upper Columbia River United Tribes, Bureau of Reclamation, Washington Department of Ecology, Washington Department of Fish and Wildlife, Columbia River Inter-Tribal Fish Commission, NMFS, and Bonneville Power Administration.

(the current 30 year average for the period of 1981 to 2010 is 87.5 MAF; this 30-year average will be updated in 2021), the draft objective is 1,278 feet in elevation; otherwise, the draft objective is 1,280 feet in elevation. To implement the LRISRP, the August 31 draft limit will be adjusted an additional amount, up to 1 foot in non-drought years and 1.8 feet in drought years (as defined by Washington Administrative Code [WAC] 173-563-056). The drought years occur when the March 1 forecast for April through September runoff at The Dalles Dam is less than 60 MAF (or an updated value to define a drought year by Washington State administrative rule, WAC 173-563-056).

DAILY OPERATIONS

The above sections describe how Reclamation operates Grand Coulee Dam across months and seasons to meet a variety of authorized purposes. Reclamation's daily operations also show how Reclamation meets the multiple purposes of power generation, safety, and resource protection while shaping flows to benefit anadromous fish.

Reclamation's coordination on regional power generation can cause releases from Grand Coulee Dam to vary widely during the day. The Mid-Columbia projects, Chief Joseph Dam, and Grand Coulee Dam are operated as one system to provide the reliability required to meet the regional power demand. Reclamation also operates Grand Coulee Dam to meet peaking operations, so it runs high during heavy load hours and reduces flow during light load hours.

Reclamation limits the daily draft of Lake Roosevelt to 1.5 feet, measured on a rolling 24-hour period to preserve reservoir bank stability. During periods of high demand, Bonneville may request a draft rate exceedance in order to meet the increased power requirements. If approved by Reclamation, draft rates may be as high as 2 feet per day, but only after Bonneville has clearly demonstrated that all other reasonable actions have been taken to meet the increased power demand.

Grand Coulee Dam also has limits to the minimum tailrace elevation and hourly tailrace drawdown rates that help maintain the river banks' stability.

LAKE ROOSEVELT INCREMENTAL STORAGE RELEASE PROGRAM

When fully implemented, the LRISRP will result in an additional foot of water to be released from Lake Roosevelt (beyond the 1,278 and 1,280 foot elevations set for the end of August to augment flow) in most years and 1.8 feet additional when the March final April through August water supply forecast falls below 60 MAF (which is the driest 4 percent of water years as currently calculated to represent a drought year by Washington State administrative rule, WAC 173-563-056, or an updated value to define a drought year by Washington State administrative rule, WAC 173-563-056). The LRISRP drawdown would result in a net increase to instream flows from Grand Coulee Dam during the April through August flow augmentation period. This is a very small increase in streamflow; however, the purpose of the drawdown is to ensure that there is no flow reduction during the juvenile salmon migration period. The timing of releases is based on the water supply forecast. Water will be delivered to the Odessa Subarea through Banks Lake, and for municipal and industrial uses and instream flows downstream of Grand Coulee Dam. The additional foot of water released from Lake Roosevelt will be refilled in September. For more detail on the release of this water, see the Action Agencies' Water Management Plan.

ODESSA SPECIAL STUDY

On April 2, 2013, Reclamation issued a Record of Decision for the Odessa Subarea Special Study (not to be confused with the water delivered to the Odessa Subarea under the LRISRP) Final Environmental Impact Statement. The preferred alternative would provide surface water supplies to about 70,000 acres of land presently irrigated with water pumped from the Odessa aquifer. At full development, this will be approximately 164,000 acre-feet. Development of the Odessa Subarea will occur in phases over approximately 10 years. This water would be delivered to the project pumping to Banks Lake from the Columbia River.

This operation was covered under separate Endangered Species Act (ESA) consultation.

ROUTINE MAINTENANCE

The range of routine or scheduled maintenance activities are discussed in Chapter 2, including drum gate maintenance and scheduled power plant maintenance. The following maintenance descriptions provide further detail for selected activities.

DRUM GATE MAINTENANCE

Reclamation's Operations and Maintenance Program requires annual inspections and dam safety maintenance for the eleven 135-foot-long, 30-foot-high drum gates. Inspection and maintenance activities can only occur when Lake Roosevelt is at or below elevation 1,255 feet for at least 8 weeks. Drum gate maintenance is planned to occur during a period between March and May annually, to coincide with the FRM drawdown of the lake. However, during dry years, FRM operations will not draft Lake Roosevelt low enough for a long enough period of time to perform necessary maintenance on the drum gates. During extended droughts or even in normal water years, when FRM operations do not require the reservoir to draft below elevation 1,255 feet for at least 8 weeks, a forced draft may be required to perform maintenance. A forced draft can reduce the chance of reaching the April 10 elevation objective and reduce downstream flows during refill, which could have negative impacts on ESA-listed species. For this reason, Reclamation agreed to criteria that would reduce the risk to ESA-listed salmon in dry years, by allowing deferral of maintenance in some dry years, to the extent possible. The criteria are as follows:

- Drum gate maintenance may be deferred in some dry water years; however, drum gate maintenance must occur a minimum of one time in a 3-year period, two times in a 5-year period, and three times in a 7-year period.
- To reduce the likelihood of having a forced draft occur in a dry year, in-season criteria were developed to guide operations in normal and wet years to accomplish drum gate maintenance. The in-season criteria are based on the FRM requirement for the April 30 maximum Grand Coulee Dam elevation, as determined by the February final of the April–August water supply forecast. The February forecast is used to allow sufficient time to draft the reservoir below 1,255 feet by March 15. These criteria are summarized in Table A-4 and described in greater detail below.
 - If the February forecast sets the Grand Coulee Dam April 30 FRM elevation at or below 1,255 feet, Grand Coulee Dam will be drafted to perform drum gate maintenance.

- When the February forecast sets the April 30 FRM requirement above 1,265 feet, drum gate maintenance will be forced only if needed to meet the requirements of the 1 in 3, 2 in 5, and 3 in 7 criteria.
- If the April 30 FRM requirement is between 1,255 and 1,265 feet, then maintenance will only be done if the following year would be a forced drum gate maintenance year. For example, if maintenance is deferred in year one because of dry conditions, and the forecasted FRM elevation is between 1,255 feet and 1,265 feet in year two, then drum gate maintenance would be accomplished in year two in order to avoid forced drum gate maintenance in year three, regardless of water supply conditions. The example above illustrates the 1 in 3 criteria, but the 2 in 5 and 3 in 7 criteria would also need to be checked.

Table A-4. Grand Coulee Dam criteria for drum gate maintenance

February FRM Requirement for Maximum April 30 GCL Elevation (feet) ^a	Drum Gate Maintenance ^b
≤ 1,255 feet	Yes
1,255–1,265 feet	If following year would be a forced drum gate maintenance year: Yes If following year would not be a forced drum gate maintenance year: No
> 1,265 feet	If in forced drum gate maintenance year: Yes If not in forced drum gate maintenance year: No

^a Maximum April 30 GCL Elevation based on the February official April–August water supply forecast for The Dalles adjusted for available storage capacity upstream of The Dalles other than Grand Coulee Dam. Monthly FRM requirements are available online at: http://www.nwd-wc.usace.army.mil/report/flood_risk/

^b Drum gate maintenance is required to meet the 1 in 3, 2 in 5, and 3 in 7 criteria.

In addition to the annual Drum Gate Maintenance, an inspection and maintenance activity is planned for the 57-inch Butterfly Drum Gate Intake Valves. Some inspection and maintenance on these valves can occur regardless of water levels, but some maintenance requires water levels at or below 1,219 feet. The external inspection and maintenance that requires water levels at or below 1,219 feet, for a week duration, with the goal of accomplishing once every 10 years. This inspection takes advantage of spring drafts for FRM, but in some years may require an additional draft below FRM requirements to conduct this maintenance. This could result in additional outflow, a longer duration of ferry outage, and elevated spill and TDG. The decision to inspect the valves will be an in-season decision depending on if the project is required to draft to elevation 1,222 feet, if refill is not triggered to be refilled in the next few weeks, and if the project can reasonably draft without violating TDG requirements.

JOHN KEYS III PUMP-GENERATING PLANT

The John Keys III Pump and Generating Plant consists of six pumps that pump water from Lake Roosevelt, behind Grand Coulee Dam, to Banks Lake, and six pump generators that can pump water to Banks Lake or generate power with water released from Banks Lake back to Lake Roosevelt. Maintenance falls under two categories; scheduled and unscheduled. The majority of the scheduled

maintenance of the pumps and pump generators occurs outside of the irrigation season, to the extent practicable. Typically, one or more pumps and/or pump generators are offline during any given time during the year. However, during the irrigation season, when pumping demand is much higher, it is desirable to have the majority of the pumps and pump generators online and available.

MAINTENANCE AT FACILITIES ON AND AROUND BANKS LAKE

Banks Lake, an offsite equalizing reservoir, is located in the upper Grand Coulee (an ancient abandoned river bed) and was built to store and supply irrigation water to the Columbia Basin Project. Banks Lake is formed by the construction of two dams: North Dam, which is near Grand Coulee Dam, and Dry Falls Dam, which is at the south end of the reservoir. Water is pumped from Lake Roosevelt through a set of pumps and pump/generators up to the Feeder Canal, which then discharges into Banks Lake. Water is released for irrigation to the Columbia Basin Project from Banks Lake through a set of gates at the headworks of the Main Canal at Dry Falls Dam.

Bulkheads are available to isolate the canal headworks and reduce the need for drawdowns to perform maintenance on the canal headworks. However, other maintenance needs may require that Banks Lake be drafted substantially below the normal operating range on occasion (up to 35 feet). The full hydrologic effects of the maintenance operations would span two different water years, with drawdown starting in August of the first water year by shutting off the pumps from Lake Roosevelt and allowing irrigation withdrawals to draft the lake by the end of October. This would result in a slight increase in flows at McNary Dam during drawdown, as water typically pumped to Banks Lake would be released from Lake Roosevelt during August. Maintenance would be performed during the winter with the goal of being completed in the spring. Refill would be coordinated with Bonneville to take advantage of high flows and low power demand to refill Banks Lake by April 15. In most years, there would be no effect to the Columbia River flow objectives during refill of Banks Lake. Adaptive management coordinated through the Technical Management Team (TMT) would be necessary in dry years to balance the requirements to meet chum flows and minimum flows through the Hanford Reach, as well as to avoid impacting the spring flows during the refill period.

During these significant drawdowns, Reclamation will coordinate with other agencies and facilities with interest around Banks Lake so that all can take advantage of the drawdown to perform any necessary maintenance activities.

At this time, there are no procedures developed that would forecast water supply prior to the first of January. As drawdown would need to be done from August through October, it would need to be scheduled without prior knowledge of what the water supply forecast might be during refill. Every effort will be made to complete maintenance in a timely manner to allow time to refill with minimal effects on spring flows.

SCHEDULED MAINTENANCE

Reclamation must perform routine maintenance at regular intervals on all units in order to comply with NERC/WECC [North American Electric Reliability Corporation/Western Electricity Coordinating Council] regulatory requirements and to ensure project reliability. With peak discharge occurring in the spring, routine maintenance is limited, to the extent possible, to minimize the number of units that must be

worked on so that as much water as possible can be passed through the turbines and not spilled. Scheduled maintenance does not affect flow; however, increased spill could result in elevated TDG saturations above the Washington State maximum standard of 110 percent saturation.

At Grand Coulee Dam, 24 generating units discharge flow to the Columbia River. Units G-1 through G-18 in the Left and Right Powerhouses have a hydraulic capacity of around 6,000 CFS each. Units G-19 through G-21 and G-22 through G-24 in the Third Powerhouse have capacities of about 25,000 CFS and 30,000 CFS each, respectively. The total hydraulic capacity of the project is determined by how many generators are online. There are typically multiple generators offline during any given time during the year for either scheduled or unscheduled maintenance.

EXTRAORDINARY MAINTENANCE

Over the next 20+ years, Grand Coulee Dam will be upgrading many of its major facilities, including all four power plants and its drum gates. Each maintenance activity has separate National Environmental Policy Act (NEPA) and ESA coverage. This section addresses each action individually and jointly. For more detail on a given action, see the NEPA document.

Routine maintenance must continue through the overhaul. During the Extraordinary Maintenance period, two units in the Third Power Plant and two in the Left and Right Power Plants will be out of service. In addition to these outages, there may be an additional forced outage of one unit in each of the Third, Left, and Right Power Plants. More details about the Third, Left, and Right Power Plant extraordinary maintenance activities are described below. These outages have the potential to affect spill and water quality (TDG) when required releases exceed the power plant hydraulic capacity, resulting in spill (bypass the turbines) through outlet tubes or over the spillway, depending on pool elevation.

Third Power Plant Overhaul

The G-19 through G-21 unit generators at the Third Power Plant are original and should be rewound (i.e., stator coils removed and replaced) every 30 years, thus, their life expectancies have been surpassed. Reclamation plans to modernize units G-19 through G-21 over a 10-year period beginning in 2020 and ending approximately 2030. The modernization would allow each unit to have a life expectancy of approximately 40 years (Reclamation 2019).

No water quality impacts from operation activities are anticipated during the overhaul of the TPP generating units. Current operation and maintenance schedules attempt to keep at least five TPP units in production during the months of December through August. More than one unit are typically removed from production in the fall months to perform needed maintenance. Joint operations with the Corps and Chief Joseph Dam can continue uninterrupted, minimizing spill events at Grand Coulee Dam and consequently minimizing TDG generation below the dam. This would not change during the overhaul and modernization of the individual TPP units. As a result, the effect on water temperature from operations throughout the overhaul period would be similar to the effect on water quality conditions from the existing conditions in both the reservoir and in the river below the dam.

Left and Right Powerplants Overhaul

The Left and Right Power Plants units 1–18 have reached their design life and are scheduled to be overhauled over a ten-year period starting 2019 or later. The objective of the overhauls is to repair and restore these machines to ensure reliable operations for an additional 30 years. In 2018, Reclamation completed an Environmental Assessment for this extraordinary maintenance (Reclamation 2018a).

John W. Keys III Pump-Generating Plant Modernization

The 12 units that comprise the JWKIII show problems stemming from wear and design that require more frequent maintenance, more challenging repairs, and longer down times. As a result, these and other components contribute to growing safety-related concerns at the plant, increase the plant operational costs, create limitations on day-to-day plant operations, and impose risks to sustained long-term operation of the plant. These issues threaten Reclamation’s contractual obligations to provide on-demand delivery of irrigation water and accommodate pumped storage at Banks Lake for balancing reserves and electrical load shaping. Modernization improvements and upgrades will not change the essential operation of Banks Lake, according to existing protocols for irrigation, load shaping, and balancing reserves; however, they may enable more rapid transitions and/or more frequent incremental changes in daily reservoir levels while the overall reservoir levels remain within established operating norms.

Modeling to support the modernization of the JWKIII (Reclamation 2012) demonstrates that pump/generating scheduled to take advantage of off-peak hour pricing to increase inflows, and then generate with the pumps/generators when power demands are high, results in more fluctuation of lake elevation but still maintains the elevation within the normal operating range. Model results show that the proposed modernization of the JWKIII would not significantly change Banks Lake elevations. Banks Lake elevations would remain within the operating range of elevation 1,565 feet to elevation 1,570 feet throughout the year. Irrigation deliveries to the Columbia Basin Project would be unaffected. The summer draft to elevation 1,565 feet for flow augmentation would be unaffected.

A.2.4.2 Hungry Horse Project

OPERATION AND MAINTENANCE

Reclamation operates and maintains all of the project’s major facilities. Operations for the Hungry Horse Project primarily include:

- Storage and release of water from Hungry Horse Reservoir
- Power generation at the Hungry Horse Powerplant
- Routine maintenance of project facilities.

The following discussion more fully describes the operations of Hungry Horse Dam and its associated facilities. Reclamation also incorporates, by reference, the standing operating procedures for Hungry Horse Dam, which more fully describe the physical facilities, operational criteria, and operating thresholds.

HUNGRY HORSE DAM MULTIPURPOSE OPERATIONS

Congress has authorized Reclamation to operate Hungry Horse Dam for the multiple purposes of irrigation, FRM, navigation, streamflow regulation, hydroelectric generation, and other beneficial uses. Reclamation also operates the dam in coordination with other CRS facilities. Not only does Hungry Horse Dam's operating range reflect variability in multiple affecting factors, such as water supply condition, hydroelectric power generation requirements, and flow needs for downstream anadromous and resident fish, but the specific operating purposes also change from month to month and season to season.

Fall Operations: September–December

During the fall season, Reclamation has two operating priorities: minimum flows at Columbia Falls for fish and FRM. The Action Agencies will implement the Northwest Power and Conservation Council's 2003 mainstem amendment, as it pertains to the end of September draft. Consistent with the mainstem amendments, the summer reservoir draft objectives at Hungry Horse are set to 3,550 to 3,540 feet. Reclamation attempts to draft Hungry Horse Reservoir by the end of September by 10 to 20 feet (elevations 3,550 to 3,540 feet), for details see description in Summer Operations (Table A-5). In some dry years, Hungry Horse will need to draft below the end of September objective to meet minimum flows at Columbia Falls.

Since implementation of the 2000 U.S. Fish and Wildlife Service and National Marine Fisheries Service (NMFS) biological opinions (BiOps), ramping rates, minimum flows, and the need to meet refill dates have limited the power operations at Hungry Horse Dam. In many years, Hungry Horse Reservoir continues to draft throughout the fall to meet minimum flows at Columbia Falls and can be an additional 15 to 20 feet down by the end of December. Ramping rates for Hungry Horse Reservoir are described in detail in Chapter 2.

To provide local flood protection in wetter falls, the Corps has established FRM criteria for Hungry Horse Reservoir. The reservoir is required not to exceed elevation 3,555.7 feet from October 31 through November 30 and elevation 3,549.2 feet by December 31.

Winter Operations: January–March

During the winter season, Reclamation's operating priorities are FRM, minimum flows for resident listed fish, and power generation. Reclamation generally drafts Hungry Horse Reservoir below the required FRM elevations to meet minimum flow requirements at Columbia Falls for resident listed fish. In water years when minimum flows do not require Reclamation to draft the reservoir below the required FRM elevations, there is some flexibility to operate for power generation. The limits to this winter power flexibility are set to provide a 75 percent probability of refilling to the April 10 elevation objective for salmon. Hungry Horse operates to VARQ (variable flow) FRM rule curves.

During January through March, Reclamation releases water while maintaining the reservoir elevation at or between the VDL⁸ and the FRM storage space requirement. The VDL is set based on an assumed inflow volume that has a 75 percent probability of occurrence while still providing the required flows at Columbia Falls and meeting the April 10 elevation objective. The VDL is calculated each month after the official water supply forecasts and FRM elevations are issued. This winter power flexibility is an important tool that is used to meet the winter power demands in the Northwest without affecting minimum fish flows or Reclamation’s ability to be at the April 10 elevation objective for salmon. This does not mean that the project will be able to fill to the April 10 elevation for 75 percent of the years—forecast uncertainty, runoff timing, and meeting minimum flows can impact the ability to reach the April 10 elevation.

Table A-5. End of September elevation draft limits for summer flow augmentation at Hungry Horse Dam

Local water supply forecast ^a	Driest 10% of years	Interpolate for water supply between the driest 10 to 20%	Wettest 80%
End of September elevation objective (feet)	3,540	3,540 to 3,550	3,550

^a Based on the May final Reclamation Hungry Horse water supply forecast from May to September. The 10th percentile, or 10% driest years is currently approximately 1.15MAF, the 20th percentile is currently approximately 1.31MAF both based on the current official 30-year period of 1981 to 2010. These values will be updated based on the next official 30-year period 1991 to 2020 in early 2021.

Spring Operations: April–June

During early and mid-spring, Reclamation typically operates Hungry Horse Dam for FRM, minimum flow requirements, and power generation. On April 30, Hungry Horse Reservoir is typically at its lowest seasonal elevation in order to capture the high flows from spring runoff and to reduce downstream flooding.

Hungry Horse FRM rule curves are designed for both local and system FRM. For the system flood protection, Reclamation coordinates with the Corps on when Hungry Horse Reservoir can begin refill in the spring. The Corps computes the initial controlled flow (ICF) at The Dalles Dam and estimates the day that level of flow is expected to be reached. When unregulated flows at The Dalles Dam are equal to the

⁸ The variable draft limit is a computed end-of-month elevation limit for drafting Hungry Horse Dam for the periods January, February, and March. The VDLs are used to provide winter power flexibility while maintaining a 75 percent probability of achieving refill of the project to its April 10 elevation objective (see April 10 URC definition).

The only variable in the computation of the VDLs is the FRM elevations. The basic computation assumes an inflow that has a 75 percent probability of occurring. The volumes needed to meet minimum flows at the project and at Columbia Falls are subtracted from the assumed inflow. The remainder is the volume available for winter power flexibility. The minimum flow required at Columbia Falls is computed based on flows in the Middle and North Forks of the Flathead River that have a 75 percent probability of occurring.

ICF, the reservoirs can start refill. Hungry Horse Reservoir can actually start refill 10 days prior to the date the ICF is expected to be met.

As spring flows increase, Reclamation no longer needs to make releases to meet minimum flows at Columbia Falls but does have a minimum flow requirement below the project on the South Fork Flathead River. As flows in the mainstem Flathead River increase, Reclamation must balance refill of Hungry Horse Dam while attempting to control flows at Columbia Falls at or below the flood stage of 14 feet (52,000 CFS) when the elevation of Flathead Lake is below the top foot (lower than 2,892 feet) and at or below a stage of 13 feet (45,000 CFS) when the elevation of Flathead Lake is within one foot of full (between elevation 2,892 and 2,893 feet). At the same time, Reclamation attempts to limit spill (flows that bypass the power plant) from the project in order to maintain TDG below the State of Montana standard of 110 percent. With the current transmission limit in the valley, this sometimes requires delaying refill to the first week in July, when inflows drop below what can be put through the generators, due to unit availability or transmission limitations. Hungry Horse may also be operated to be below the April 30 FRM point so that it can reduce the outflows during refill to prevent spills that would result in TDG above the limit.

Reclamation typically tries to refill Hungry Horse Reservoir by June 30. However, as mentioned previously, the timing and shape of the spring runoff may result in reservoir refill a few days before or after the June 30 target date. For example, a late snowmelt runoff may delay refill to sometime after June 30 in order to avoid excessive spill and/or surcharge of the reservoir. Local weather conditions such as precipitation may also have an influence.

Summer Operations: July–August

During the summer season, Reclamation's operating priorities are flow augmentation for fish, and refill for resident fish. In accordance with the Northwest Power and Conservation Council's 2003 mainstem amendments recommendation Hungry Horse will be operated to balance flow augmentation with storage for resident fish. In wetter years, refill can be delayed until mid- July. After the refill period, Hungry Horse Dam releases are set to meet the September 30 elevation objectives. Reclamation attempts to drafts Hungry Horse Reservoir by the end of September by 10 to 20 feet (elevations 3,550 to 3,540 feet). These draft objectives are 3,540 feet in the driest 10 percent of years, linearly interpolating between 3,550 and 3,540 feet in the driest 10 percent to 20 percent driest years, and 3,550 feet in the other years (Table A-5). These reservoir drafts are meant to support summer flows for juvenile salmon migration downstream of Chief Joseph Dam. In some dry years, Hungry Horse will need to draft below the end of September objectives to meet minimum flows at Columbia Falls.

Hungry Horse releases are calculated to either operate at a constant release from July through September or to gradually decline outflows in an attempt to provide a beneficial flow regime for resident fisheries below the project. Occasionally, Reclamation will not fill completely (to elevation 3,560 feet) in order to transition from FRM releases to flow augmentation releases; this prevents dropping outflows to a minimum (900 CFS) just to fill to elevation 3,560 feet, then immediately increasing discharges to start the summer flow augmentation regime.

SELECTIVE WITHDRAWAL STRUCTURE MAINTENANCE

Hungry Horse Reservoir thermally stratifies in the summer and can provide some downstream water temperature management through use of the selective withdrawal structure (SWS). The SWS is required to be operated from June to end of September but is typically operated into November when the reservoir becomes isothermal and the benefits of SWS operations are negated. The SWS has an operational range when the reservoir is between full (3,560 feet) and drafted 160 feet (3,400 feet). Annually, inspection and maintenance is planned in the spring. The reservoir must be at or below elevation 3,526 feet to allow for annual inspection and maintenance (with the relief gate hanging, the bottom of the gate is located at 3,526 feet, allowing for access by maintenance personnel (lowered via man-basket from the top of dam gantry crane) for inspection and repair. Note that missing or damaged relief gate panels or other related equipment restricts or potentially disables the function of the SWS. Continuance of routine maintenance of this system is critical to ensure reliable uninterrupted operation of temperature-controlled water releases for fish. Reclamation maintenance directives dictate annual maintenance.

The SWS inspection, maintenance, and repair is planned to occur annually during late April or early May. When site conditions disallow spring maintenance (flood control/reservoir elevation/weather conditions), maintenance is deferred to the fall, if reservoir elevations allow, or the following spring. However, deferral of such maintenance is not recommended for the previously noted reasons (e.g., restricted or loss of SWS function). If deferral occurs for several consecutive years reshaping refill to allow maintenance may be necessary. This inspection takes advantage of spring drafts for FRM. The reservoir must be at or below elevation 3,526 feet NGVD29 in order to complete SWS inspection and maintenance.

PLANT MODERNIZATION

In any given year additional outages can occur because of NERC/WECC requirements or unexpected events/equipment failures, which may limit the ability to pass water through the power plant and in some cases may result in additional spill. Reclamation is planning a Hungry Horse Powerplant Modernization and Overhaul Project (Reclamation 2018b) in the next 10 years. This overhaul would take place over 4 years, currently scheduled to start approximately 2020 or 2021. During one of the 4 years maintenance would require outages for one year in the power plant, limiting the power plant to two units available for one year, reducing the hydraulic capacity to approximately 6 kcfs. This could result in additional spill in this one year, and the maximum TDG anticipated from the overhaul study was 120 percent. In most years the reduced hydraulic capacity would not result in significantly more spill and would not result in higher TDG than presented in this analysis. As spill typically occurs during the spring when it is cold it takes substantial increase in spill to raise TDG above 115 percent, often during this period the resident fish have migrated out of South Fork Flathead River that time of year, and elevated TDG is diluted when flowing into the mainstem Flathead River.

KERR DROUGHT MANAGEMENT PLAN

In 1996, Kerr Dam (renamed Sèliš Ksanka Ólispè⁹ in 2015) went through a Federal Energy Regulatory Commission (FERC) relicensing process, authorized under the Federal Power Act (FERC 2006). Under Section 4(e) of the Federal Power Act, FERC must consider environmental requirements within the Federal reservation. Through the licensing process, it was discovered that during low-water years, there is insufficient water to achieve FERC license Article 43 lake levels at Flathead Lake and maintain the flow requirements downstream under Article 56, which were developed by the Secretary of the Interior, acting under Section 4(e) of the Federal Power Act. Article 60 under the license required the development of a Drought Management Plan to address these concerns.

The Drought Management Plan established operational provisions to avoid and resolve potential water-use conflicts in years where there is insufficient water to meet the requirements of Articles 43 and 56 (when inflow to Flathead Lake is less than 72.6 percent of normal [about 1 in 18 years]).

The Bureau of Indian Affairs prepared a Drought Management Plan Final Environmental Impact Statement in 2009 (BIA 2009); under Article 61 of the license, Reclamation will coordinate releases required under the ESA. Reclamation will coordinate operations with the Corps and the Confederated Salish Kootenai Tribes in accordance with the Drought Management Plan should water supply conditions result in not being able to meet the criteria listed in Articles 43 and 56.

A.3 U.S. ARMY CORPS OF ENGINEERS MIDDLE COLUMBIA RIVER RUN-OF-RIVER PROJECT – CHIEF JOSEPH DAM

A.3.1 General Description

The Corps operates a run-of-river project on the middle Columbia River. Chief Joseph Dam is located at RM 545, approximately 1.5 miles upstream from Bridgeport, Washington, and 51 miles downstream from Grand Coulee Dam. The reservoir created by Chief Joseph Dam is called Rufus Woods Lake. It extends 51 miles upstream (to Grand Coulee Dam) and has a shoreline length of 106 miles.

A.3.2 Authorization

The River and Harbor Act of 1946 authorized the construction, repair, and preservation of certain public works on rivers and harbors for hydropower generation, navigation, irrigation, and other purposes. Chief Joseph Dam was initially authorized as Foster Creek Dam and Powerhouse under this Act dated July 24, 1946 (Pub. L. No. 79-525, 79th Congress, 2nd Session), and in accordance with the survey report dated April 9, 1946, submitted by the Chief of Engineers in House Document 693 (79th Congress, 2nd Session July 3, 1946). Foster Creek Dam was renamed Chief Joseph Dam by the River and Harbor Act of 1948 (Pub. L. No. 80-858). Recreation is authorized through the Federal Water Project Recreation Act of July 9, 1965 (Pub. L. No. 89-72) and under the Flood Control Act of 1944 (Pub. L. No. 78-534). Fish and

⁹ The Confederated Salish Kootenai Tribes took over operations of Kerr Dam in 2015. They renamed it Sèliš Ksanka Ólispè (pronounced SHE-leesh k-SAHN-kah qw-leese-PEH), which means Salish Kootenai Pend Oreille in their language.

Wildlife Conservation is authorized by the Fish and Wildlife Coordination Act of 1958 (Pub. L. No. 85-624) and the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Pub. L. No. 96-501).

The project was originally authorized for 17 generation units in 1946. Phase I construction of the dam and units 1 through 16 began in 1949 and were completed in 1958. Construction began again on July 11, 1969, in response to recommendations for a ten foot pool raise to a maximum pool elevation of 956 feet and to complete the 11 additional units included under the original authorization. Phase II construction for units 17 through 27 began in 1973 and were completed in 1979.

Authorization for water quality is granted under Pub. L. No. 92-500.

A.3.3 Authorized Purposes and Description of Projects

Congressional authorization was provided to allow Chief Joseph Dam to operate for multiple purposes, including hydropower generation and navigation. Subsequent legislation has augmented the missions of the Corps, and Chief Joseph Dam currently also operates in the interest of recreation and fish and wildlife conservation.

The elevation of Rufus Woods Lake fluctuates very little throughout the year. The normal operating range is between elevation 950 feet and 956 feet. Although the project was authorized to fluctuate between elevation 930 feet and 958.8 feet, a number of constraints make actual operation over that full range unlikely, and elevation 950 feet is considered the year-round normal minimum forebay elevation for Chief Joseph project.

Chief Joseph Dam is a run-of-river project, and while FRM was not an initial objective, the dam and Rufus Woods Lake have been, and continue to be, regulated to help provide FRM, though on a limited scale. Summary information for Chief Joseph Dam is presented in Table A-6.

Table A-6. Chief Joseph Dam summary information

Dam	Type of Dam	Year Completed ^a	River Mile	Reservoir Name	Usable Capacity (acre-feet)
Chief Joseph	Run-of-River	1979	545	Rufus Woods Lake	116,000

^a Chief Joseph Dam was constructed in two phases. Phase I was completed in 1958; Phase II was completed in 1979.

The dam consists of a 19-bay gated concrete gravity spillway that abuts the right bank and connects to a curved non-overflow concrete section founded on a rock outcropping. The intake structure and powerhouse follow a downstream alignment and connect with the left abutment by means of a curved concrete gravity non-overflow dam. The 2,047-foot powerhouse encloses 27 main generators, two station service generators, maintenance shops and control room, and the visitor center. The area of Rufus Woods Lake at full pool is 8,400 acres, and its gross capacity at full pool is 593,000 acre-feet. The reservoir is 51 miles long and has a shoreline length of 106 miles.

Chief Joseph Dam was constructed primarily to provide hydroelectric power. Based on historical information, the minimum gross hydropower head is 162 feet. Assuming all 27 units are operating at their highest output, the maximum output is estimated to be 2,440 MW. This estimate is based on

recent index tests and historical model tests. Maximum powerhouse discharge is estimated to be approximately 215,000 CFS.

Total project real estate interest administered by the Corps is 16,123 acres, of which 12,006 acres are easement lands. The balance is primarily designated wildlife mitigation lands and public domain lands; 318.18 acres of Corps fee and easement lands are managed for recreation. The Confederated Tribes of the Colville Reservation exercise control over portions of the north shoreline in Okanogan County, which lies within Colville Indian Reservation boundaries. Reclamation has jurisdiction over lands upstream from RM 590.4. In addition, the U.S. Bureau of Land Management administers substantial areas of public land adjoining the lake in Douglas County on the south bank. Several state-managed parcels of land also exist in Douglas County.

A.4 U.S. ARMY CORPS OF ENGINEERS LOWER SNAKE RIVER PROJECTS

A.4.1 General Description

The Lower Snake River Project is the name for the Corps' series of four dams on the lower Snake River: Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, and Ice Harbor Dam.

The Snake River projects include an authorized navigation channel 250 feet wide by 14 feet deep, measured at minimum operating pool in each reservoir, which extends from the confluence of the Snake and Columbia Rivers to a point at RM 1.3 on the Clearwater River at Lewiston, Idaho. This channel is the upper end of the Columbia-Snake River Inland Waterway, which includes the deep draft navigation channel on the lower Columbia River and is an important link for regional, national, and international commerce.

All four lower Snake River dams are run-of-river facilities, meaning that they are not authorized, designed, or operated for FRM. These facilities have limited storage capacity and pass water at nearly the same rate as the water enters each reservoir. Reservoir levels behind these dams vary only a few feet during normal operations. This limited storage is used for regulation of powerhouse discharges to follow hourly, daily, and weekly demand patterns, but is not enough to allow seasonal regulation of streamflows.

A.4.2 Authorization

The lower Snake River projects were constructed and are operated and maintained under laws that may be grouped into three categories: (1) laws initially authorizing construction of the project; (2) laws specific to the project passed subsequent to construction; and (3) laws that generally apply to all Corps projects within the United States. Using these and other authorities, the Corps operates multiple-use water resource development projects to balance operation of individual functions with operations for all functions. This operation is coordinated with Bonneville, Reclamation, and other regional interests. Authorized uses for the lower Snake River projects are hydropower generation, inland navigation, fish and wildlife conservation, incidental irrigation, and recreation. Project purposes have been authorized under several public laws. Construction of the lower Snake River projects for the purposes of navigation, hydropower production and incidental irrigation was authorized under Pub. L. No. 79-14. Recreation was included as a project purposed under the authority of Pub. L. No. 78-534. Fish and wildlife

conservation is a project purposed under the authority of Pub. L. No. 85-624 and the Water Resources Development Act of 1976 (Pub. L. No. 94-587), which approved the Lower Snake River Compensation Plan.

A.4.3 Authorized Purposes and Description of Projects

The four lower Snake River dams are multiple-use facilities that provide public benefits in a number of different ways. Project facilities include dams and reservoirs, hydroelectric power plants and high-voltage transmission lines, navigation channels and locks, juvenile and adult fish-passage structures, parks and recreational facilities, levee systems, lands dedicated to project operations, and areas set aside as wildlife habitat. While it is physically possible to draw run-of-river reservoirs well below their normal minimum pool levels, the four lower Snake River facilities are not designed to operate below minimum pool levels.

Summary information is presented for the four lower Snake River projects in Table A-7. More detailed information is presented for each project in Table A-8.

The Lower Snake River Project was originally designed and constructed with adult passage facilities at the four dams. These facilities include fish ladders, pumped attraction water supplies, and powerhouse fish collection systems, and have certain features in common. In general, there is a set of main fishway entrances near one end of the spillway, between the spillway and powerhouse, and at the other end of the powerhouse. Two entrances are typically used at each location, and additional smaller entrances (floating orifice gates) are provided across the face of the powerhouse.

Lower Granite Dam was the only dam on the Columbia and Snake Rivers constructed to accommodate a screened juvenile bypass system. Improved facilities were added to Little Goose Dam in 1980. The Columbia River Fish Mitigation Program began in the late 1980s, leading to a system-wide project for evaluation of mitigation needs and implementation of improvements at the Corps' four lower Snake River and four lower Columbia River dams beginning in 1991. Under this program, new juvenile fish bypass/collection facilities were constructed at Ice Harbor Dam (1996), Lower Monumental Dam (1993), and Little Goose Dam (1990). Additional improvements have been made as new technology develops. Other improvements (i.e., spillway flow deflectors at Ice Harbor Dam and Lower Monumental Dam and extended submerged bar screens at Little Goose Dam and Lower Granite Dam) have also been added. Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam have facilities for collecting and transporting juvenile fish. Spillway weirs have been installed at the facilities to improve in-river migration of juvenile fish through more effective spill programs. Weirs were installed at Lower Granite Dam in 2001, at Ice Harbor Dam in 2005, at Lower Monumental Dam in 2008, and at Little Goose Dam in 2009. Juvenile fish migrating downstream have several routes for passing the projects: through the spillway, through the juvenile bypass system, through a spillway weir, or through the turbine units. Spill for juvenile fish passage is provided at all lower Snake River dams during the passage season, usually from early April through the end of August. Spill for juvenile fish is developed annually in concert with the TMT and FPOM ([Fish Passage Operations and Maintenance], a regional coordination group having representatives of federal agencies and non-federal sovereigns) and described in the Fish Operating Plan (Appendix E of the Fish Passage Plan).

Table A-7. Lower Snake River Project summary information

Facility	Type of Dam	Year Completed	Snake River Mile	Reservoir Name	Usable Capacity ^a (acre-feet)
Ice Harbor	Run-of-River	1961	9.7	Lake Sacajawea	25,000
Lower Monumental	Run-of-River	1969	41.6	Lake Herbert G. West	20,000
Little Goose	Run-of-River	1970 ^b	70.3	Lake Bryan	49,000
Lower Granite	Run-of-River	1975 ^c	107.5	Lower Granite Lake	49,000

Source: Corps and NMFS 1994

^a Normal operating range

^b The Little Goose facility was open to navigation in May 1970. The installation of power generating units 1 through 3 was completed in March 1970. Additional power units 4 through 6 were installed, and power came online in July 1978.

^c Additional power units 4 through 6 were installed, and power came online in April 1978.

Table A-8. Lower Snake River Project Facility operations and structures

Specification	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Reservoir				
Normal Pool Operating Range (feet above NGVD) ^a	437–440	537–540	633–638	733–738
Total Length (miles)	31.9	28.7	37.2	43.9
Surface Area (acres) ^b	9,002	4,960	10,825	8,448
General (Dam)				
Dam Length (feet)	2,822	3,791	2,655	3,200
Hydraulic Head (feet)	100	100	98	100
Powerhouse				
Powerhouse Length (feet)	671	656	656	656
Nameplate Capacity (MW)	600	810	810	810
Total Number of Units Installed	6	6	6	6
Spillway				
Spillway Length (feet)	590	498	512	512
Number of Spillway Bays	10	8	8	8
Stilling Basin Length (feet)	168	180	118	188
Navigation Lock and Channels				
Lock Chamber Length (feet)	675	666	668	675
Lock Chamber Width (feet)	86	86	86	86
Maximum Operating Lock Lift (feet)	105	103	101	105
Navigation Channel (at minimum operating pool) extending from mouth of Snake River to Lewiston/Clarkston at Clearwater River Mile 1.3	250 feet wide by 14 feet deep	250 feet wide by 14 feet deep	250 feet wide by 14 feet deep	250 feet wide by 14 feet deep

^a NGVD = National Geodetic Vertical Datum^b At normal operating pool elevation (highest level of range)

A.4.3.1 Lower Granite Dam

Lower Granite Lock and Dam (usually referred to as Lower Granite Dam) is located on the Snake River at RM 107 near Almota, Washington. Lower Granite Lake, the reservoir behind Lower Granite Dam, extends 39.3 miles upstream on the Snake River and further 4.6 miles on the Clearwater River. Lewiston, Idaho, is located 33 miles upstream of the dam. Lower Granite Dam is authorized for navigation, hydroelectric power, recreation, and fish and wildlife conservation. Lower Granite Dam was placed into service in 1975 and includes, from south to north, five major components: fish-passage facilities, powerhouse, spillway, navigation lock, and non-overflow embankment. The dam, located at the head of Lake Bryan, is 3,200 feet long, with an effective height of 100 feet.

The normal operating range of Lower Granite Lake extends from 733 to 738 feet. The powerhouse is 656 feet long and 243 feet wide, and houses six 135 MW generators. Next to the powerhouse is a 512-foot concrete spillway equipped with steel Tainter gates, each 50 feet wide by 60 feet high. The spillway has eight spill bays, each 50 feet wide. A concrete-lined stilling basin extends 188 feet downstream from the spillway along the river bottom.

The navigation lock at Lower Granite is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the 756-foot north dam embankment.

Juvenile fish-passage facilities at Lower Granite Dam consist of a bypass system, spillway weir, and transportation facilities. Adult fish-passage facilities include one fish ladder on the south shore, a powerhouse collection system, adult fish trap, and an auxiliary water supply system. The fish ladder has been modified in recent years to improve passage conditions for Pacific lamprey.

There are 9,220.4 acres of project lands surrounding Lower Granite Lake, including fee lands that are federally owned and managed by the Corps, as well as easement lands on which the Corps has designated rights (i.e., flowage or access). Approximately 515 acres are leased to state or local public agencies. Port districts own lands adjacent to the project for industrial development. The majority of these project lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

There are 13 developed recreation areas adjacent to Lower Granite Lake, with boat ramps, moorage/marina facilities, day-use facilities, and campgrounds.

There are several habitat management units (HMUs) totaling 5,002 acres along Lower Granite Lake. Water pumped from the reservoir is used to irrigate one of these HMUs.

Water is withdrawn from Lower Granite Lake by municipal and industrial pump stations. The water is used for municipal water system backup, irrigation, and industrial purposes. There are three port facilities on Lower Granite Lake (Lewiston, Clarkston, and Wilma).

A.4.3.2 Little Goose Dam

Little Goose Lock and Dam (usually referred to as Little Goose Dam) is located on the Snake River at RM 70.3 near Starbuck, Washington. Little Goose Reservoir, known as Lake Bryan, extends 37.2 miles

upstream to Lower Granite Dam. The project is authorized for hydroelectric power, navigation, recreation, irrigation, and fish and wildlife conservation.

Little Goose Dam was placed into service in 1970, and includes, from south to north, several major components: navigation lock, fish-passage facilities, powerhouse, spillway, and non-overflow embankment. The dam, located at the head of Lake Herbert G. West, is 2,655 feet long with an effective height of 98 feet. The normal operating range of Lake Bryan extends from 633 feet to 638 feet. The powerhouse is 656 feet long and 243 feet wide, and houses six 135-MW generators. Next to the powerhouse is a 512-foot concrete spillway equipped with steel Tainter gates, each 50 feet wide by 60 feet high. The spillway has eight spill bays. A concrete-lined stilling basin extends 118 feet downstream from the spillway along the river bottom.

The navigation lock at Little Goose project is a single-lift type facility; it is 668 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 101 feet. Next to the navigation lock is the north dam embankment.

Juvenile fish-passage facilities at Little Goose consist of a bypass system, spillway weir, and transportation facilities. Adult fish-passage facilities are composed of one fish ladder on the south shore, a powerhouse collection system, and an auxiliary water supply system. The fish ladder has been modified in recent years to improve passage conditions for Pacific lamprey.

There are 4,859.6 acres of project lands surrounding Lake Bryan, including both fee and easement lands. The majority of the Corps-managed lands are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Currently, two areas of approximately 150 acres each are leased either to the state or local ports for recreation.

There are seven developed recreation areas adjacent to Lake Bryan with boat ramps, a marina, day-use facilities, and campgrounds. There are multiple HMUs, totaling 3,019 acres, along the reservoir. Water pumped from the pool is used to irrigate two of these HMUs. There are three port facilities on Lake Bryan (Almota, Central Ferry, and Garfield).

A.4.3.3 Lower Monumental Dam

Lower Monumental Lock and Dam (usually referred to as Lower Monumental Dam) is located on the Snake River at RM 41.6 near Kahlotus, Washington. The reservoir at Lower Monumental, known as Lake Herbert G. West, extends 28.7 miles upstream to Little Goose Dam. The project is authorized for hydroelectric power, navigation, recreation, fish and wildlife conservation, and irrigation.

Lower Monumental was placed into service in 1969 and includes, from south to north, the following major components: south non-overflow embankment, navigation lock, fish-passage facilities (also located between the powerhouse and the north non-overflow embankment), spillway, powerhouse, and the north non-overflow embankment. The Lower Monumental Dam, located at the head of Lake Sacajawea, is 3,791 feet long, with an effective height of 100 feet. The normal operating range of Lake West is from 537 to 540 feet. The powerhouse is 656 feet long and houses six 135 MW generators. Next to the powerhouse is a 498-foot concrete spillway equipped with steel Tainter gates. The spillway has eight spill bays, each 50 feet wide. The Tainter gates are each 50 feet wide by 60 feet high. A concrete-lined stilling basin extends 180 feet downstream from the spillway on the river bottom.

The navigation lock at Lower Monumental is a single-lift type structure, and is 666 feet long by 86 feet wide, with a 14-foot minimum operating depth and a maximum lift of 103 feet. Next to the navigation lock is the 968-foot north dam embankment. Juvenile fish-passage facilities at Lower Monumental Dam consist of a bypass system, spillway weir, and transportation facilities. Adult fish-passage facilities include north and south shore fish ladders, a powerhouse collection system, and an auxiliary water supply system. The fish ladders have been modified in recent years to improve passage conditions for Pacific lamprey.

There are 9,143.6 acres of project lands surrounding Lake West, including both fee and easement lands. Port districts own land for industrial development both on and adjacent to project lands. The majority of Corps-managed lands, 7,024.0 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development. Approximately 1,177 acres are leased to the State of Washington for Lyons Ferry State Park.

There are six developed recreation areas adjacent to the Lake West, with boat ramps, a marina, day-use facilities, and a campground. There are multiple HMUs totaling 4,381 acres along the reservoir. Water pumped from the Lower Monumental pool is used to irrigate two of these HMUs. There is one port on the reservoir (Lyons Ferry).

A.4.3.4 Ice Harbor Dam

Ice Harbor Lock and Dam (usually referred to as Ice Harbor Dam) is located on the Snake River at RM 9.7 near Burbank, Washington. Major cities in the local vicinity include Kennewick and Pasco, which are located upstream of the confluence of the lower Snake and Columbia Rivers, and Richland, which is located at the confluence of the Yakima and Columbia Rivers. Ice Harbor Lock and Dam is authorized for hydroelectric power, navigation, irrigation, recreation, and fish and wildlife conservation.

The reservoir at Ice Harbor Dam, known as Lake Sacajawea, extends 31.9 miles upstream to Lower Monumental Dam. Ice Harbor Dam was placed into service in 1961 and includes, from south to north, the following major components: fish-passage facilities (located between the spillway and the navigation lock), powerhouse, spillway, navigation lock, and non-overflow embankment. The dam is 2,822 feet long, with an effective height of 100 feet. The normal operating range of Lake Sacajawea extends from 437 to 440 feet. The powerhouse is 671 feet long and houses three 90 MW and three 110 MW generators. Next to the powerhouse is a 590-foot concrete spillway equipped with steel Tainter gates. The spillway has ten spill bays, each 50 feet wide. The Tainter gates are each 50 feet wide by 52.9 feet high. A concrete-lined stilling basin extends 168 feet downstream from the spillway along the river bottom.

The navigation lock at Ice Harbor Dam is a single-lift type, 675 feet long by 86 feet wide, with a 15-foot minimum depth and a maximum lift of 105 feet. Next to the navigation lock is the north dam embankment, which is 624 feet long.

Juvenile fish-passage facilities at Ice Harbor Dam consist of a bypass system, juvenile sampling facilities, and a spillway weir. Adult fish-passage facilities are made up of separate north and south shore facilities. The north shore facilities include a fish ladder, a small collection system, and an auxiliary water supply system. The south shore facilities comprise a fish ladder, a powerhouse collection system, and an auxiliary water supply system. The fish ladders have been modified in recent years to improve passage

conditions for Pacific lamprey. In addition to small-scale fishway modifications, a lamprey entrance structure was installed at one of the south shore fish ladder entrances to provide an alternative, lower-velocity route into the fish ladder.

There are 4,037.7 acres of project lands surrounding Lake Sacajawea, including both fee and easement lands. The majority of the Corps-managed lands, 3,517.3 acres, are used for public recreation, wildlife habitat, wildlife mitigation, and water-connected industrial development.

Seven developed recreation areas lie adjacent to Lake Sacajawea, including boat ramps, a marina, moorage facilities, and campgrounds. There are several HMUs totaling 2,032 acres along the reservoir. Water pumped from the pool is used to irrigate three of these HMUs. There are two ports on Lake Sacajawea (Windust and Sheffler).

Approximately 37,000 acres of non-federal land are presently irrigated with water pumped from Lake Sacajawea. There are approximately 75 pumps located at the 14 irrigation pumping stations along the reservoir.

A.5 U.S. ARMY CORPS OF ENGINEERS LOWER COLUMBIA RIVER PROJECTS

A.5.1 General Description

The Corps operates four projects on the lower Columbia River: Bonneville Dam, The Dalles Dam, John Day Dam, and McNary Dam.

Bonneville Dam, The Dalles Dam, and McNary Dam are run-of-river projects and are not operated for FRM. These projects have limited storage capacity and pass water at nearly the same rate as the water enters each reservoir. Reservoir levels behind these dams vary only a few feet during normal operations. This limited storage is used for regulation of powerhouse discharges to follow daily and weekly demand patterns. This storage is not enough to allow seasonal regulation of streamflows. John Day Dam was developed for FRM, as well as for hydropower and navigation, and is considered a storage facility. While John Day Dam has allocated FRM storage, it is typically operated in a manner that is similar to other mainstem dams that are run-of-river projects.

A.5.2 Authorization

The Columbia River projects were constructed and are operated and maintained under laws that may be grouped into three general categories: (1) laws initially authorizing project construction; (2) laws specific to the projects passed subsequent to construction; and (3) laws that generally apply to all Corps projects within the United States. Using these and other authorities, the Corps operates multiple-use water resource development projects to balance operation of individual functions with operations for all functions. This operation is coordinated with Bonneville, Reclamation, and other regional interests. Authorized uses for the lower Columbia River dams include FRM, power generation, navigation, fish and wildlife conservation, irrigation, and recreation.

A.5.3 Authorized Purposes and Description of Projects

The lower Columbia River dams are multiple-use projects that provide public benefits in a number of different ways. Project facilities include dams and reservoirs, hydroelectric power plants and high-voltage transmission lines, navigation channels and locks, juvenile and adult fish-passage structures, fish hatcheries, parks and recreational facilities, lands dedicated to project operations, and lands managed in support of habitat for various species. The projects' primary functions are to produce hydroelectric power and provide navigation on the Columbia River as part of the Columbia-Snake River Inland Waterway. Land for public access and recreation is limited at Bonneville Dam and The Dalles Dam because of minimal Corps management and physical constraints (i.e., topography and highway and railroad development paralleling both shores). The John Day and McNary projects have fewer limitations and more land under Corps management.

Summary information is presented for the four lower Columbia River projects in Table A-9. More detailed information is presented for each project in Table A-10.

Table A-9. Lower Columbia River Projects summary information

Dams	Type of Dam	Year Completed	River Mile	Reservoir Name	Usable Capacity (acre-feet)^a
Bonneville	Run-of-River	1938	145.5	Lake Bonneville	100,000
The Dalles	Run-of-River	1960	192.5	Lake Celilo	53,000
John Day	Storage	1971	215.6	Lake Umatilla	535,000
McNary	Run-of-River	1957	292.0	Lake Wallula	185,000

^a Usable capacity = water occupying active storage capacity of a reservoir

Table A-10. Lower Columbia River Projects facility operations and structures

Specification	Bonneville (B1) ^a	Bonneville (B2) ^a	The Dalles	John Day	McNary
Reservoir					
Normal Pool Operating Range (feet above NGVD)	70–77	-	155–160	257–268	335–340
Total Length (miles)	48	-	23.6	76.4	61.6
Surface Area (acres)	20,600	-	9,400	49,300	38,800
FRM Storage (acre-feet)	0	-	0	500,000	0
General (Dam)					
Dam Length (feet)	2,477	-	8,735	5,900	7,365
Hydraulic Head (feet)	50	-	85	105	83
Powerhouse					
Powerhouse Length (feet)	1,027	986	2,089	1,975	1,422
Nameplate Capacity (MW)	612.5	612	1,807	2,160	986
Total Number of Units Installed	10	8	24	16	14
Spillway					
Spillway Length (feet)	1,070	-	1,467	1,288	1,320
Number of Spillway Bays	18	-	23	20	22
Stilling Basin Length (feet)	147	-	170	182	276
Navigation Lock and Channels					
Lock Chamber Length (feet)	500	675	650	675	675
Lock Chamber Width (feet)	76	86	86	86	86
Maximum Operating Lock Lift (feet)	70	70	90	113	84

^a Data for Bonneville Dam are presented by powerhouse. The first powerhouse (B1) went into operation in 1938. The second powerhouse (B2) was completed in 1981.

Juvenile fish migrating downstream have several routes for passing lower Columbia River projects: through the spillway, through the juvenile bypass system, through a surface flow outlet, or through the turbine units. Spill for juvenile fish passage is provided at all lower Columbia River dams during the passage season, usually from April 10 through the end of August. Spill for juvenile fish is developed

annually in concert with the TMT and FPOM and described in the Fish Operating Plan. See Table 2-4 in Chapter 2 of this Proposed Action.

A.5.3.1 McNary Dam

McNary Lock and Dam (usually referred to as McNary Dam) is located on the Columbia River at RM 292 near Umatilla, Oregon. Major cities in the local vicinity include Umatilla and Hermiston, which are near the dam; Kennewick and Pasco, located upstream of the confluence of the Snake and Columbia Rivers; and Richland, located at the confluence of the Yakima and Columbia Rivers. Construction of McNary Dam was authorized for the purposes of hydropower generation, navigation, incidental irrigation and general fish and wildlife conservation under Pub. L. No. 79-14. Recreation was included as an authorized project purpose under Pub. L. No 78 534.

Lake Wallula, the reservoir behind McNary Dam, extends 42.7 miles upstream to Ice Harbor Dam on the Snake River and 58 miles upstream to Columbia River mile 350. McNary Dam was placed into service in November 1954.

McNary Dam has several major components. From south to north, they are: the south non-overflow embankment and adult fish-passage facilities (also located between the spillway and the navigation lock), the powerhouse, spillway, navigation lock, and north non-overflow embankment.

The powerhouse, with 986,000 kilowatts of installed generating capacity, has 14 main generators rated at 70,000 kilowatts and two auxiliary station service units of 3,000 kilowatts each.

Juvenile fish-passage facilities at McNary Dam consist of a bypass system, two spillway weirs, and transportation facilities. Adult fish-passage facilities are made up of separate north and south shore facilities. The north shore facilities include a fish ladder, a small collection system, and an auxiliary water supply system. The south shore facilities include a fish ladder, powerhouse collection system, and auxiliary water supply system.

Juvenile fish-passage facilities were added to McNary Dam in the early 1980s. The facilities were modified in 1994, with the construction of a new juvenile bypass system and transportation facilities. Extended-length bar screens were installed in 1996 and 1997. A new juvenile bypass outfall was completed in early 2012 to improve the survival of juvenile fish passing through the juvenile bypass system.

Two spillway weirs were constructed in 2007 to provide more efficient passage and improve the survival of juvenile salmonids passing McNary Dam.

The adult fish-passage facilities at McNary Dam include a north shore fish ladder that passes fish from entrances at the north end of the spillway, and a north shore gravity auxiliary water supply system. Northern Wasco County People's Utility District installed a turbine unit on this auxiliary water supply in the 1990s, changing the system from a high-head system to a low-head system. Fish passage on the south side of the river is accomplished with a south shore fish ladder that passes fish from entrances along a collection channel that extends the full length of the powerhouse. Auxiliary water is provided by a combination of gravity flow from the forebay and pumped water from the tailrace. Counting stations are provided in both fish ladders. The south shore fish ladder features a lamprey passage entrance structure designed to provide Pacific lamprey with an alternative, lower-velocity entrance to the fish

ladder. Other lamprey passage features, such as small orifices in ladder weirs, are integrated in both fish ladders.

There are 13,562 acres of fee-owned project lands surrounding Lake Wallula. An additional 5,530 acres of privately owned lands have flowage easements. The majority of Corps-managed lands are used for public recreation, wildlife habitat, project structures and levees, and water-connected industrial development. There are 17 HMUs totaling 8,414 acres managed for wildlife habitat. A total of 3,530 acres are leased to the USFWS as part of McNary National Wildlife Refuge. Water pumped from the pool is used to irrigate two of these HMUs.

There are 22 developed recreation areas adjacent to Lake Wallula. Ten of these areas are managed by the Corps, while others are managed by the USFWS, Oregon State Parks, Washington State Parks, Benton County, and the cities of Richland, Kennewick, and Pasco (Tri-Cities).

There are eight port sites on Lake Wallula used for the transportation of grain, wood products, fertilizers, fuel, and other commodities. McNary project lands are adjacent to agricultural, municipal, and commercial developments, and therefore, there are numerous agricultural, industrial, and municipal pumping stations along the reservoir, along with stormwater and sewer outfalls. Reclamation maintains two facilities on McNary project lands for providing water to local irrigation districts as part of the Umatilla River water exchange program.

A.5.3.2 John Day Dam

John Day Lock and Dam (usually referred to as John Day Dam) is located 24 miles upstream from the Dalles Dam at the head of Lake Celilo at RM 215.6. The authorized purposes of the project are FRM, navigation, irrigation, recreation, fish and wildlife conservation, and hydropower generation. Pub. L. No. 81-516, § 204, 64 Stat. 163 (May 17, 1950) (Flood Control Act of 1950); Pub. L. No. 78-534, § 4, 58 Stat. 887 (December 22, 1944) (Flood Control Act of 1944) (authorizing recreational facilities at Corps reservoirs). The facility consists of a navigation lock, spillway, powerhouse, non-overflow sections, and fish-passage facilities on both shores. Construction began in 1958 and the first power generator went into operation in 1968. Lake Umatilla is the second largest reservoir on the Columbia River and provides for navigation, with a minimum 14-foot depth in the main channel. The navigation lock, located on the Washington shore, is 86 feet wide and 669 feet long, and provides 15 feet of water depth over the sills, with a 113-foot maximum lift.

The powerhouse, with 16 main generators of 135 MW capacity each, has a total generating capacity of 2,160 MW. The last of the 16 generators went online in November 1971.

Unlike the other dams on the lower Columbia River, John Day Dam is also operated for FRM. When high runoff is forecast, the Lake Umatilla pool is lowered to provide space for control of about 500,000 acre-feet of floodwaters.

Juvenile fish-passage facilities at John Day Dam consist of a screened juvenile bypass system and two spillways weirs. The adult fish-passage facilities at John Day Dam are composed of north and south shore fish ladders.

Juvenile fish bypass facilities at John Day Dam, completed in 1987, include one vertical barrier screen, one submerged traveling screen, and one 14-inch-diameter orifice per gatewell, with three gatewells for

each of the 16 turbine units, for a total of 48 orifices. The new smolt monitoring facility was completed in 1998. The bypass collection conduit leads to a transport channel that carries collected juvenile fish to the river below the dam when the smolt monitoring facility is not in operation (bypass mode). Water level differential between the forebay and bypass conduit is controlled by the Tainter gate, and has a criterion of four to five feet (water level in the conduit is measured at unit 16).

In 2010, two spillway weirs were constructed to facilitate downstream juvenile fish passage at the spillway. In addition, an extended-length flow deflector was added to spill bay 20 to improve tailrace juvenile fish egress and reduce TDG production during spill operations.

The adult fish-passage facilities at John Day Dam include a north shore fish ladder that passes fish from entrances at the north end of the spillway, and a south shore fish ladder that passes fish from entrances along a collection channel that extends the full length of the powerhouse. Auxiliary water is provided to all collection systems by pumping from the tailrace. Counting stations are provided in both fishways. Both fish ladders have been modified in recent years to improve passage conditions for Pacific lamprey. The north fish ladder was extensively modified to improve both salmon and lamprey passage.

In addition to the two visitor areas at John Day Dam, recreation is available at more than a dozen areas along Lake Umatilla. Most of the areas are managed by the Corps, but there are also parks operated by local entities in several locations. Total acreage for the John Day project, including pool, fee lands, and lesser interests, is more than 52,000 acres.

A.5.3.3 The Dalles Dam

The Dalles Lock and Dam (usually referred to as the Dalles Dam) is located on the Columbia River at RM 192.5, approximately 90 miles east of Portland, Oregon, and three miles upstream from the city of the Dalles, Oregon. The development and construction of The Dalles Lock and Dam project was authorized by the Flood Control Act of 1950. Construction began in 1952 and was completed in 1960. Project authorized purposes include irrigation, navigation, recreation, fish and wildlife conservation, and hydropower. Pub. L. No. 81-516, § 204, 64 Stat. 163 (May 17, 1950) (Flood Control Act of 1950); Pub. L. No. 78-534, § 4, 58 Stat. 887 (December 22, 1944) (Flood Control Act of 1944) (authorizing recreational facilities at Corps reservoirs).

The Dalles Dam extends 1.5 miles from the Oregon shore to the navigation lock on the Washington shore. The project consists of a navigation lock, spillway, powerhouse, fish-passage facilities, and the non-overflow sections of the dam. Various recreational facilities are provided along Lake Celilo, the 24-mile-long impoundment behind the dam.

Lake Celilo provides navigation at a minimum depth of 15 feet in the main channel. The facility's navigation lock, on the Washington shore, is 86 feet wide and 675 feet long. It has an 88-foot normal lift and provides a 15-foot minimum depth over the sills.

The powerhouse, with 1,807 MW of installed generating capacity, has 22 main generators—14 original units rated at 78 MW and eight newer units rated at 86 MW—and two auxiliary units of 13.5 MW each. The auxiliary units also provide water to attract adult migrating fish to the fish ladders.

Juvenile and adult fish are able to pass downstream at the Dalles Dam via a sluiceway and the spillway. Turbine units at the Dalles Dam are not screened. Upstream migrant passage facilities consist of a north shore fish ladder and an east fish ladder.

Juvenile fish passage consists of the modified former sluiceway and one 6-inch orifice in each gatewell. The sluiceway is a rectangular channel extending along the total length of the 22-unit powerhouse and is located in the forebay side of the powerhouse. Gatewell orifices allow flow into the sluiceway, providing a potential means of passing fish from the gatewells to the sluiceway. When any of the sluiceway gates (located in the forebay side of the sluiceway) are opened, water and juvenile migrants are skimmed from the forebay into the sluiceway and deposited in the tailrace downstream of the project. In 2004, a spillway divider wall (spillwall) was constructed between spill bays 6 and 7 in order to improve the survival of juvenile fish that pass through the spillway. In 2010, an extended-length spillwall was constructed between spill bays 9 and 10 to further improve the survival of juvenile fish passing the spillway.

Adult fish-passage facilities at The Dalles Dam include a north shore fish ladder, which passes fish collected at the north end of the spillway, and an east fish ladder that passes those fish collected at the south end of the spillway and across the downstream face of the powerhouse. The east fish ladder has been modified in recent years to improve passage conditions for Pacific lamprey. A small hydropower facility, utilizing the north fishway ladder auxiliary water supply, was constructed in 1991 and is operated by the Northern Wasco County Public Utility District. Adult fishway criteria associated with this facility are monitored and maintained during the daily fishway inspections. A backup auxiliary water supply system, unscreened for juveniles, has been upgraded to facilitate its use, if required.

There are several recreation sites on both the Washington and Oregon shores at the Dalles Dam. Some are operated by the Corps; others are operated by the states of Oregon or Washington. Total acreage for the Dalles project, including pool, fee lands, and lesser interests, is more than 12,000 acres.

A.5.3.4 Bonneville Dam

Bonneville Lock and Dam (usually referred to as Bonneville Dam) is located at the head of tidewater on the Columbia River at RM 145.5, in the heart of the Columbia River Gorge, approximately 42 highway miles east of Portland, Oregon. The Oregon-Washington State boundary lies along the main Columbia River channel, dividing the project between the two states. The facility includes two navigation locks, two powerhouses, one spillway, fish-passage facilities, a fish hatchery, and one of the largest visitor complexes administered by the Corps.

In 1937, the 75th Congress authorized the completion, maintenance, and operation of the facility under the Corps' supervision and, in 1938, the first powerhouse went into operation. The original authorized project purposes are navigation, fish and wildlife conservation, and hydropower, with recreational opportunities added as an authorized use later. Pub. L. No. 73-67, § 202, 48 Stat. 195 (June 16, 1933) (National Industrial Recovery Act of 1933) (authorizing the Federal Emergency Administrator of Public Works to develop hydropower, transmit electricity, construct river improvements, and control floods as recommended by Chief of Engineers); Pub. L. No. 74-409, 49 Stat. 1028 (Aug. 30, 1935) (River and Harbor Act of 1935); Pub. L. No. 75-329, § 1, 50 Stat. 731 (Aug. 20, 1937) (Bonneville Project Act); Pub. L. No. 78-534, § 4, 58 Stat. 887 (December 22, 1944) (Flood Control Act of 1944) (authorizing recreational

facilities at Corps reservoirs). A second powerhouse was completed in 1981, which more than doubled generating capacity. Bonneville Lock and Dam was placed on the National Register of Historic Places in June 1986 and includes a National Historic Landmark District. The old navigation lock is no longer operational. The new navigation lock at Bonneville opened to traffic in 1993. The new navigation lock is 675 feet long by 86 feet wide, with a maximum lift of 70 feet.

Juvenile fish-passage facilities for downstream-migrating fish at Bonneville Dam are powerhouse and spillway specific. Fish entering the first powerhouse (B1) pass either deep through turbine units or may pass through a shallower route over lowered gates into a debris-type sluiceway. The spillway, sited between the Bradford and Cascades Islands, has 18 vertical-lift gates used for passing flow in excess of powerhouse discharge and/or for smolt passage. The second powerhouse (B2) connects to the Washington shore on the north end and is separated from the spillway on the south end by Cascades Island. The second powerhouse contains eight screened turbine units (i.e., juvenile bypass system). A modified sluiceway, referred to as the B2 corner collector, is the result of extensive modification of the original B2 chute. Adult fish-passage facilities for upstream migrants include the Bradford Island ladder, the Cascades Island ladder, and the Washington Shore ladder. Some upstream migrating fish pass via the navigation lock as well.

Juvenile fish-passage facilities at the first Bonneville powerhouse (B1) consist of chain gates and a sluiceway converted in 2010 to a surface flow outlet for downstream juvenile fish passage. In addition, the first powerhouse has been retrofitted with new main turbine units that have incorporated features to increase survival of fish passing through them.

Juvenile fish-passage facilities at the second Bonneville powerhouse (B2) include streamlined trash racks, STSs, and vertical barrier screens. There are two 12.5-inch orifices per gatewell in units 11 to 14 and in fish unit 2, and one 12.5-inch orifice in all other gatewells, all flowing into a fish bypass channel, a dewatering facility, and a 48-inch fish transport pipe that connects the bypass channel to a mid-river release point approximately 1.5 miles downstream. Transport pipes (48 inches) at the high and low outfall transport fish to the tailrace at the outfall location. A juvenile fish sampling facility is included in the bypass. Two smaller turbines that supply adult fishway auxiliary water do not have STSs or streamlined trashracks; however, they have a fine trashrack with a 0.75-inch clear opening. B2 is also equipped with a surface flow outlet to provide a safe and efficient passage route for downstream-migrating fish. The B2 corner collector is located on the south side of the powerhouse. The associated flume extends several thousand feet west on the south side of the B2 tailrace, and empties at the tip of Cascades Island.

Adult fish-passage facilities at Bonneville Dam consist of two main fishway segments. The B1 collection channel and A-branch ladder join the south spillway entrance and B-branch ladder at the junction pool at the Bradford Island ladder to form the Bradford Island fishway. The Cascades Island ladder at the north side of the spillway is connected to the Washington Shore ladder by the upstream migrant transportation channel. The B2 collection channel and north and south monoliths join the upstream migrant transportation channel to form the Washington Shore fishway. Bradford Island, Cascades Island, and the Washington Shore fishways have counting stations. The Washington Shore ladder has an adult fish sampling facility. All four collection systems have auxiliary water supplies for fish attraction. The B1 auxiliary system is gravity supplied, while the B2 system is fed by two 15 MW fish turbines and water is introduced at the B2 junction pool. All fish ladders at Bonneville Dam have been modified in recent

years to improve passage conditions for Pacific lamprey. In addition to small-scale features and a modified entrance weir design at Cascades Island fish ladder, a large entrance bypass structure was installed at the north downstream entrance of the Washington Shore fish ladder. Flume-like Lamprey Passage Structures (LPSs) that serve as bypass structures around conventional fishways have been installed at all three fish ladders.

Developed recreation areas around Bonneville Lock and Dam and Lake Bonneville include the dam visitor center, campground, state parks, and boat basins. The Bonneville Dam facilities drew nearly 2.74 million recreational visits in fiscal year 2005. Total acreage for the Bonneville project, including pool, fee lands, and lesser interests, is more than 25,000 acres.

A.6 REFERENCES

BIA (Bureau of Indian Affairs). 2009. Final Environmental Impact Statement for a Drought Management Plan for Operation of the Kerr Hydroelectric Project on Flathead Lake, Montana.

Corps and NMFS (U.S. Army Corps of Engineers and National Marine Fisheries Service). 1994. Draft Lower Snake River Biological Drawdown Test Environmental Impact Statement. April 1994.

FERC (Federal Energy Regulatory Commission). 2006. Kerr Project License Ordering Paragraphs & Articles (as amended through August 11, 2006). Retrieved August 14, 2017 from http://energykeepersinc.com/wp-content/uploads/2013/08/Kerr_License-Public_Web.pdf.

Reclamation (U.S. Bureau of Reclamation). 2012. Finding of No Significant Impact Final Environmental Assessment: John W. Keys III Pump-Generating Plant Modernization Project. U.S. Department of Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho, and Ephrata, Washington. March 2012.

Reclamation (U.S. Bureau of Reclamation). 2018a. Finding of No Significant Impact and Final Environmental Assessment: Grand Coulee G1 through G18 Generating Units Modernization and Overhaul. Pacific Northwest Region, Boise, ID and Grand Coulee Power Office, Grand Coulee, Washington.

Reclamation (U.S. Bureau of Reclamation). 2018b. Bureau of Reclamation Finding of No Significant Impact for Hungry Horse Powerplant Modernization and Overhaul Project final environmental impact statement. Bureau of Reclamation, Pacific Northwest Region. Boise, Idaho.

Reclamation (U.S. Bureau of Reclamation). 2019. Third Power Plant G19-G21 Modernization Project Final Environmental Assessment, Grand Coulee Project, Washington. U.S. Department of Interior, Bureau of Reclamation, Grand Coulee Power Office, Grand Coulee, WA.

**Consultation Package for
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**APPENDIX B – ACTIONS TAKEN BY BONNEVILLE POWER ADMINISTRATION IN
MANAGING THE FEDERAL TRANSMISSION SYSTEM THAT CAN INFLUENCE
WATER MANAGEMENT ACTIONS AT THE PROJECTS CONSULTED ON IN THIS
DOCUMENT**

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

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B.1 GENERAL DESCRIPTION

Hydroelectric power generation is one of the authorized purposes of the 14 dam and reservoir projects in the Columbia River System (CRS) that are operated as a coordinated water management system. Transmission facilities owned and operated by Bonneville Power Administration (Bonneville) interconnect and integrate electric power generated at the dams to the regional transmission grid, enabling the transmission of power produced at CRS dams to serve loads (demand for electricity) in the Pacific Northwest and to be exported to other regions. Bonneville owns, operates, and maintains 75 percent of the high-voltage transmission system in the Pacific Northwest, which is interconnected with regional utilities and generators, as well as Canada to the north, California to the south, and Utah and other states to the east. Bonneville's transmission system also interconnects, integrates, and transmits the electric power generated from non-federal generating plants in the Pacific Northwest, including non-federal dams, nuclear, thermal, gas and coal plants, wind and solar generation projects, and transmits power generated outside the Northwest into or through the region.

B.2 AUTHORIZATION

Bonneville is authorized by the Bonneville Project Act, the Flood Control Act, the Federal Columbia River Transmission System Act, and the Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act) to construct, operate, maintain, and improve the federal transmission system in the Pacific Northwest. The Energy Policy Acts of 1993 and 2005 authorized the Federal Energy Regulatory Commission (FERC) to order Bonneville to provide transmission access, and established the North American Electric Reliability Corporation (NERC) Electric Reliability Organization and mandatory reliability standards applicable to Bonneville, respectively. NERC established a functional model for reliability entities responsible for implementing the reliability standards. These functional entities include reliability coordinators,¹ balancing authorities,² and transmission operators,³ among other entities. Bonneville is certified as both a balancing authority and a transmission operator, in addition to other functions. Peak Reliability currently serves as the reliability coordinator for the Western interconnection within the United States, but will no longer provide reliability coordinator services after December 2019. Bonneville intends to take reliability coordinator services from the California Independent System Operator starting as early as November 2019.

¹ The reliability coordinator is the entity responsible for the real-time reliability of the Bulk Electric System within its reliability coordinator Area. The reliability coordinator monitors the entire reliability coordinator area and has authority to direct other functional entities, including balancing authorities and transmission operators, to take action to ensure reliable operations of the Bulk Electric System.

² The balancing authority is the entity responsible for maintaining generation-load-interchange balance within its balancing authority area and monitoring interconnection frequency in real-time.

³ The transmission operator is the entity responsible for the real-time reliable operation of transmission system assets and load, generation, and inter-system interconnections in its transmission operator area. The transmission operator has authority to direct certain actions to ensure reliable operations.

B.3 RELATIONSHIP BETWEEN THE FEDERAL TRANSMISSION SYSTEM AND WATER MANAGEMENT AT COLUMBIA RIVER SYSTEM PROJECTS

Bonneville, as both the balancing authority and the transmission operator, must operate according to mandatory reliability requirements set by various federal laws and regulations and guidelines, or by operating instructions from the regional reliability coordinator. At certain times, transmission system operations for reliability or Bonneville's obligation to balance power generation to match load within the balancing authority area to comply with the mandatory reliability standard requirements, including maintaining operating reserves, may have an impact on the coordinated water management of the CRS. Actions to assure electrical transmission system reliability, including water management responses to planned and emergency transmission outages and operating power reserve obligations that may affect the coordinated water management at the projects are described below.

B.3.1 Transmission Operations

Periodically, to assure the reliability of the transmission system when system conditions warrant, it is necessary to increase or decrease the amount of water flowing through a project's turbines and spill bays at one or more of the affected CRS projects. If any of the transmission system conditions listed below are present and can be alleviated by temporarily modifying generation levels at one or more federal projects, the Action Agencies will adjust generation and spill levels to avoid the transmission system impact. These events could result in actual spill being temporarily higher or lower than the target fish passage spill level. Such events may occur in anticipation of or coincident with the transmission system event or in subsequent hour(s) if the event affects water balance at a specific hydro project or river reach. Bonneville will work to restore conditions to support target spill operations as soon as practicable. These actions are taken to minimize the risk and/or scope of a transmission system emergency.

B.3.1.1 Standard Operations for Transmission Reliability

The Action Agencies manage the 14 CRS projects to be prepared to provide electric reliability support as follows:

1. Ensuring sufficient range of generation capability is available to provide the Bonneville balancing authority area with contingency reserves required by NERC reliability standards.
2. Ensuring generation is available to increase or decrease in order to balance load and generation within the Bonneville balancing authority area to support reliability and comply with related balancing authority area reliability standards.
3. Ensuring enough generating units are online and have sufficient capability to increase or decrease generation to meet the Bonneville balancing authority area frequency response obligations, consistent with reliability standard requirements.
4. Ensuring that there is generation operating at projects in specific locations sufficient for arming for Remedial Action Schemes (RASs). RASs allow the transmission system to automatically respond to unplanned events on the power system by immediately dropping or reducing generation at those specified locations.

5. Maintaining minimum generation levels at generators in specific locations to maintain correct voltage levels on the power system to assure reliability.
6. Maintaining enough generation units online in diverse locations on the electrical grid to assure system stability through rotating inertia.

B.3.1.2 Contingency Operations for Transmission Reliability

If the routine reliability tools described above are insufficient to resolve the transmission condition, the Action Agencies will implement the preemptive actions detailed in the Power System Emergency Action Plan (Attachment 1 to the Technical Management Team Emergency Protocols) if time permits. Where necessary, the 14 CRS projects will be called upon to relieve the following conditions:

- Increasing or decreasing generation at projects (redispatch) in specific geographic locations to relieve heavily loaded transmission lines if required by system conditions. This includes adjusting generation that flows over specific transmission facilities to keep flows over those paths within the requirements of NERC reliability standards.
- Increasing or decreasing generation to assure transmission system stability and/or reliable load service in local areas under specific system conditions. (For example, increasing generation at Ice Harbor Dam to support transmission stability, including providing load service to the Tri-Cities area of Washington, when system conditions require.)
- Responding to unanticipated significant events, including NERC Energy Emergency Alerts or other system emergencies, consistent with the Power System Emergency Action Plan included as Attachment 1 to the Technical Management Team Emergency Protocols.
- Other unanticipated significant events (e.g., powerhouse fires, earthquakes, etc.)

B.3.1.3 Planned and Unplanned Transmission Outages

Bonneville owns, operates, and maintains the federal transmission system. This includes responsibility for maintaining the electrical reliability of the system, which requires continuous monitoring and maintenance to meet applicable reliability standards.

NERC has been certified by FERC as the Electric Reliability Organization under Section 215 of the Federal Power Act, with authority to develop and enforce mandatory reliability standards on all users, owners, and operators of the Bulk-Electric System, including Bonneville. NERC has delegated some of its authority to the Western Electricity Coordinating Council to monitor and enforce reliability standards and create regional variances in the Western interconnection.

NERC reliability standards also establish minimum maintenance requirements. To comply with these maintenance requirements and to accommodate necessary additions, improvements, or reinforcements, including repair to or replacement of damaged equipment, outages may be required to take the transmission equipment out of service to perform the necessary work. A planned outage is scheduled to repair or replace equipment as needed, before it fails, or to accommodate interconnections or new or upgraded transmission facilities. Unplanned outages occur when automatic devices detect a problem, such as lightning, storm or ice damage, fires, fallen trees, equipment failure, or human-caused events, any of which may require removal of the equipment from service for repair or

replacement. This is necessary for safety purposes and for the protection of the grid and interconnected generation or loads. The loss of transmission capacity due to outages may create conditions that necessitate altering reservoir operations to reduce or increase the amount of water passing through a project's hydroelectric turbines to assure that adequate energy is provided to the system at the right locations to meet demand without overloading the transmission system or violating NERC standards.

Bonneville performs continuous outage analyses to identify the optimal timing for planned outages, manage risks, and communicate the likelihood of outages and probable effects. Bonneville also coordinates transmission and generation outages as part of the regional outage coordination process required by the applicable reliability coordinator procedures implementing certain of the mandatory reliability standards.⁴ The Action Agencies have long-term and short-term planning procedures in place to avoid or minimize the effects of planned transmission outages on operations at the federal dam and reservoir projects to conserve fish and wildlife, as described in Chapter 2, Sections 2.1.3 and 2.1.7. This includes scheduling planned outages outside of the spring and summer fish passage seasons, where practicable. That said, conducting timely transmission maintenance and making needed upgrades or additions to the transmission system are necessary activities to maintain system reliability. These planned maintenance activities are designed to reduce the risk of unplanned outages that could take longer to resolve and/or be more difficult to control and could potentially have a greater adverse effect on both the transmission system and on fish operations. Restoration of the system after unplanned interruptions may also take longer than returning the system to normal conditions for planned transmission outages because, among other things, the crews and equipment necessary to respond were not anticipated. Under certain circumstances, therefore, it is better to schedule planned outages to conduct maintenance or install upgrades or additions, even if those activities may affect fish operations (e.g., during the spring and summer migration seasons for salmon and steelhead) than to delay transmission system maintenance actions and risk unplanned and potentially more extensive outages.

In circumstances where a planned or unplanned outage may constrain fish operations at the CRS projects, Bonneville will coordinate any necessary adjustments to fish spill operations per the procedures described above and in the annual Fish Operations Plan

B.3.1.4 Voltage Stability

Additionally, generation at the CRS dam and reservoir projects operates to maintain the voltage profile across the federal transmission system through each plant's automatic voltage control. A time-of-day voltage schedule is set at all projects to assure optimal voltage to support power transfers, as well as to maintain reactive capability at the generators for contingency response. This results in minimum generation requirements at CRS projects that are essential to maintain proper voltage regulation under a wide variety of outage conditions, as well as the varying load and power transfer conditions.

⁴ Peak Reliability currently administers the Outage Coordination Process in compliance with NERC Reliability Standard IRO-017-1. Bonneville also has been working with the California ISO on Outage Coordination Procedures that it will implement as a reliability coordinator.

B.3.1.5 Reliability Congestion Management

Bonneville must also manage congestion and constraints on the transmission system. At times, this may require the Bonneville transmission operator to issue transmission schedule curtailments and generation redispatch to reduce excessive power flows on the transmission system. Schedule curtailments have the effect of reducing generation that is the source of the schedule. The Bonneville transmission operator may also increase or decrease federal generation in specific locations of the transmission system (redispatch) to relieve and redirect the power flows that are contributing to the transmission constraints for reliable transmission operations.

B.3.1.6 Remedial Action Schemes

Bonneville also supports the transfer capability of certain internal transmission paths and major regional interties through the use of RAS. One type of Bonneville RAS involves generation dropping, which allows Bonneville transmission operators to automatically offload areas of the transmission system to quickly mitigate transient, voltage, and thermal constraints for a range of contingency events.

For example, the largest generation-dropping RAS requires 2,850 megawatts (MW) to support 3,100 MW of the total transfer capability at the Nevada-Oregon border of the High-Voltage Direct Current (DC) Intertie between Celilo, Oregon, and Sylmar, California. If the DC intertie is operating at the full 3,100 MW export total transfer capacity at the Nevada-Oregon border and it is lost, then 2,850 MW of generation must be dropped or shed to protect the parallel alternating-current transmission system. In other words, if there is a sudden outage reducing capacity on the intertie, generation at some CRS projects must be reduced. This RAS is tied to four federal projects (Grand Coulee Dam, Chief Joseph Dam, McNary Dam, and The Dalles Dam).⁵ If the DC intertie is required for full export of energy to California, which is likely during the spring freshet, then these federal plants may be required to support up to the full 2,850 MW of generation-dropping RAS. If RAS is tripped, then the turbine units in the CRS that are armed for RAS events will automatically drop, taking the generation to zero. The system may have to adjust the amount of water passing through a project's hydroelectric turbine if generation is tripped by a RAS event.

B.3.2 Balancing Authority

In addition to transmitting and marketing the power generated at the CRS projects and other facilities, Bonneville is also responsible for maintaining the balance between generation and load within Bonneville's balancing authority area. Energy supply, including generation, imports, and exports, must equal load (demand for electricity) at all times. To accomplish this, Bonneville manages and provides operating reserves based on required reserve obligations using dispatchable generation. The most common dispatchable power plants for meeting reserve obligations in the Northwest are hydropower and natural gas. Therefore, Bonneville sets aside a certain portion of hydropower generation capability to meet its reserve obligations for unexpected increases or decreases in generation or load in its balancing authority area. These unexpected changes in generation can come from variable energy generation like wind, sudden generation outages, or sudden transmission congestion mitigation. As of

⁵ Additional DC Intertie RAS capacity is provided by 15 wind farms, if generation is available.

July 31, 2018, Bonneville has approximately 2,764 MW of wind capacity installed in its balancing authority area.⁶ Over the last 2 years, several wind project owners electronically moved their projects to other balancing authority areas, decreasing Bonneville's reserve requirements. These reserve requirements continue to change with the amount of resources that choose to be located in the Bonneville balancing authority. Adjustments to water management to assure adequate reserves from the CRS are most likely to occur during high spring flows in the months of May and June.

B.3.2.1 Balancing Reserves

Balancing reserves are necessary to deal with the inherent variability between scheduled and delivered energy and demand within a balancing authority area. Certain reliability standards developed by NERC and adopted by FERC set requirements governing the actions of balancing authority entities. Like other utilities, Bonneville is required to comply with reliability standards developed in accordance with the Federal Power Act.⁷ As the balancing authority, Bonneville is required to carry balancing reserves to meet unanticipated power demands, including deployment of those reserves by adjusting certain CRS projects in response to schedule variations for generation and load, both increases or decreases, within its balancing authority area. Having these reserves available is vital to maintain system reliability. Without such reserves, system reliability issues necessitating generation or schedule curtailments would be more common. Almost all loads and generators have some amount of variation between their actual hourly energy used or provided and the amount scheduled. Currently, Bonneville relies primarily on the CRS to meet its balancing reserve obligations.

To maintain the reliability of the transmission system, Bonneville deploys the reserves at the CRS projects to assure generation-load balance and support interconnection frequency. Deployment is primarily accomplished using automatic generation control. Automatic generation control is a computerized management system that instructs specified hydroelectric generators to follow variations in load demand and generation production in the balancing authority area by increasing or decreasing the amount of water passing through the turbines, down to 2-second intervals.

The actual output of variable generation such as wind power frequently varies from the scheduled amount in greater magnitudes than loads or traditional dispatchable generators such as thermal or hydro resources. Therefore, variable generation requires a wider range of balancing reserves. In part because of this variability and the increase in wind generation in the system since 2008 (from about 1,500 MW to 2,764 MW, as of July 31, 2018), the amount of CRS capacity Bonneville must set aside to provide balancing reserves has more than doubled.

For most of the spring and summer fish passage season, Bonneville can meet balancing reserve requirements without interfering with fish operations at the CRS projects. During periods of high river flows, however, which may last for weeks at a time during the spring season, maintaining capacity on the CRS to comply with balancing reserve requirements may result in an adjustment from planned fish

⁶ The total installed generation capacity in the Bonneville balancing authority as of July 31, 2018 is 28,443 MW. Additional information about interconnected and integrated wind generation can be found at http://transmission.bpa.gov/business/operations/Wind/WIND_InstalledCapacity_Plot.pdf.

⁷ 16 U.S.C. § 824o(b)(1).

passage spill levels and/or higher total dissolved gas (TDG) levels. There may also be several hours each year when deploying balancing reserves could result in temporary adjustments to planned fish spill operations. This condition generally occurs at CRS projects during periods when planned fish passage spill levels constitute a percentage of hourly flow.

In certain conditions it may be necessary to reduce the level of reserves provided by the CRS for short durations because of unexpected outages at these projects or other interruptions. In such circumstances, to maintain load and resource balance on the transmission system in compliance with applicable reliability standards, Bonneville may limit generation to schedules or initiate actual curtailments to generation schedules for short durations. Bonneville may also attempt to purchase replacement reserves from non-federal resources, where practicable.

B.3.3 Oversupply Conditions

Large amounts of variable generation, combined with surplus quantities of hydropower generation, a condition which is most likely to occur during the spring runoff, may result in generated electricity that is greater than the total regional and extra-regional market demands, leading to a potential oversupply of energy generated in the Bonneville balancing authority area and in the region. Oversupply on Bonneville's system occurs most frequently during hours of low electricity use, such as early in the morning. Under these conditions, the river flow that is greater than the amounts needed to generate electricity for regional load and export market needs and that cannot be stored in reservoirs must be spilled. This can result in TDG levels that exceed water quality standards.

To manage TDG levels in such circumstances, Bonneville maximizes hydropower generation to meet regional and extra-regional market demands and offers low-cost or free federal power generation to displace other electric power generators, such as coal, natural gas, and other dispatchable power plants, as well as variable generators.

Typically, under circumstances when federal power is available at low or no cost, the thermal plants shut down to save fuel costs. With renewable energy incentives and the level of installed variable generation in Bonneville's balancing authority area, many variable generators have chosen to meet their market demands and not to shut down voluntarily without receiving payment to cover their costs to take their generation offline, including the loss of these incentives or other contractual delivery requirements.

Therefore, Bonneville has adopted the Oversupply Management Protocol, which allows Bonneville to displace generation within the balancing authority area with federal energy during periods of oversupply. For variable generation, Bonneville displaces these generators in exchange for compensation for the variable generators' economic losses. The Protocol serves as a tool to help manage TDG levels within applicable water quality standards for the protection of both Endangered Species Act-listed and non-listed fish and other aquatic biota.

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**APPENDIX C – COLUMBIA RIVER MAINSTEM DEPLETIONS ASSOCIATED WITH
RECLAMATION’S COLUMBIA BASIN PROJECT AND OTHER TRIBUTARY
IRRIGATION PROJECTS**

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

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C.1 INTRODUCTION

The Columbia River drains about 219,000 square miles in the United States and 39,500 square miles in Canada. Observed outflow of the Columbia River averages about 198 million acre-feet (MAF) per year. Irrigation (both federal and non-federal) accounts for most surface water withdrawals in the Columbia River Basin. This appendix describes the Bureau of Reclamation's (Reclamation's) federal irrigation project depletions on the mainstem Columbia River. The action includes the mainstem Columbia River hydrologic depletions for the Columbia Basin [irrigation] Project (CBP). Also, as a matter of convenience, Reclamation is including cumulative depletions on the mainstem Columbia River for six (6) of Reclamation's irrigation projects that are not operated in coordination with the Columbia River System (CRS). Four of these irrigation projects are located on tributaries to the Columbia River, and consultations on these have been, or are in the process of being, conducted separately (see Table C-1); however, the analysis in these separate consultations ends at the confluence of the Columbia River and does not include mainstem effects. Two of the six irrigation projects are simply pump facilities located on the mainstem Columbia River. Depletions from all these irrigation projects are included in the CRS mainstem flow models and accounted for in the CRS modeling.

C.2 HYDROLOGIC EFFECTS OF RECLAMATION'S COLUMBIA BASIN PROJECT

C.2.1 Columbia Basin Project

Grand Coulee Dam is the primary storage and diversion structure for the CBP. Irrigation diversions are pumped from Lake Roosevelt to Banks Lake via the John W. Keys III Pump/Generating Plant (JWKIII). Operation for the CBP irrigation diversions are coordinated with other authorized project purposes in a complex operational regime. For more information on operations of Grand Coulee Dam for multiple purposes, including flood risk management (FRM), see Appendix A.

The irrigation season extends from about mid-March to November 1. For the purposes of this consultation, the action diverts up to 3.4 MAF¹ annually—this includes an additional 45 kaf that is a new action as part of this Proposed Action. (Depletions by month are provided in Table C-2).

This total of 3.4 MAF includes a small section (3,460 acres) of the CBP is served by the Burbank Pumps at Blocks 2 and 3, which pump from the Snake River (McNary Pool) near the confluence with the Columbia River to lands located south of the Snake River. The maximum pumping rate at the Burbank pumps is about 60 cfs, with a total diversion of about 23,000 acre-feet of water, of which about 10,000 acre-feet return to the river through seepage and surface return flows.

This total of 3.4 MAF also includes other irrigation diversions for the CBP that are already part of the environmental baseline; these include 164,000 acre-feet covered by the Odessa Subarea Special Study 2012 Final Environmental Impact Statement and corresponding Section 7 Endangered Species Act (ESA) consultation (Reclamation 2012a). These diversions occur at the JWKIII.

¹ This includes 30,000 acre-feet diverted through JWKIII for the Lake Roosevelt Incremental Storage Releases Project covered under a June 2009 Environmental Assessment.

C.2.1.1 General Project Description

Reclamation operates and maintains all the CBP's major facilities. Operations for the CBP primarily include storage in and release of water from Lake Roosevelt by operations of Grand Coulee Dam, and storage and release of water to Banks Lake by diversion of water at the JWKIII. Aside from operations of Grand Coulee Dam, diversions at the JWKIII, and flow augmentation from Banks Lake, Reclamation does not further coordinate the operation of the CBP with the CRS.

C.2.1.2 Water Supply

Lake Roosevelt has an active capacity of 5.2 MAF and a total capacity of 9.4 MAF. The average annual Columbia River inflow to Lake Roosevelt is approximately 77 MAF.

The JWKIII, on the left bank of Lake Roosevelt just upstream from Grand Coulee Dam, was designed to accommodate 12 pumping units to pump water for irrigation delivery from Lake Roosevelt to the 1.6-mile-long long Feeder Canal that leads to Banks Lake. The JWKIII features

- six pumps, each with an approximate capacity of 1,600 cfs, depending on pool elevations,
- two pump/generators with a pumping capacity of 1,605 cfs each and a generating capacity of 50 MW, and
- four pump/generators units with a pumping capacity of 1,700 cfs each and a generating capacity of 53.5 MW.

If Lake Roosevelt is below elevation 1,240 feet, the pump/generators are not available, leaving only the six pumps to deliver water to Banks Lake. The six pumps do not have the capacity to meet full demand, so when demand exceeds the capacity of the six pumps, water must be drafted from Banks Lake to supplement flows. Banks Lake is then refilled when Lake Roosevelt elevation is high enough to allow use of the pump/generators.

Banks Lake, located in an old ice-age channel called the Grand Coulee, is a reregulating reservoir. This 27-mile-long reservoir is formed by the North Dam, which is located about 2 miles southwest of Grand Coulee Dam, and the Dry Falls Dam, which is located about 29 miles south of Grand Coulee Dam. Banks Lake has an active storage capacity of 715,000 acre-feet, feeds water to the CBP through the Main Canal at Dry Falls Dam, and provides water to operate the pump/generators in generation mode at JWKIII. Return flows from the CBP are routed back to the Columbia River through several wasteways; Table C-3 reports the return flows lumped as returns to the pools above Wanapum, Priest Rapids, and McNary Dams as they appear in the Bonneville Power Administration's (Bonneville's) 2010 Level Modified Streamflow report (Bonneville 2011). These points were selected because they are points where National Marine Fisheries Service (NMFS) has established flow objectives.

C.2.1.3 Depletion Effects on the Mainstem Columbia River

This appendix only addresses the diversions for irrigation; impacts due to FRM at Grand Coulee Dam are reflected in Chapter 2 and in Appendix A.

C.3 HYDROLOGIC EFFECT OF RECLAMATION'S NON-CRS IRRIGATION PROJECTS

In addition to the CBP and as a matter of convenience, Reclamation is including in this consultation the Columbia River mainstem hydrologic depletions of six of Reclamation's irrigation projects that are not operated in coordination with the CRS. Chief Joseph Dam [Irrigation] Project and The Dalles Dam [Irrigation] Project pump water directly from the Columbia River and operate for a single purpose: water delivery. The Crooked River Project, Deschutes Project, Umatilla Project, and Yakima Project are tributary irrigation projects that operate to meet multiple purposes; the two main purposes that affect mainstem Columbia River flows are associated with irrigation water storage and delivery and reshaping of flows to provide for local FRM. Reclamation has ongoing or completed consultations with the NMFS and the U.S. Fish and Wildlife Service (USFWS) for these projects to address tributary effects of irrigation project operations on listed species (see Table C-1 for the current status of tributary irrigation project consultations). The effects analysis for each tributary consultation was confined to the tributary and did not include mainstem effects. This consultation will evaluate the mainstem hydrologic depletions due to the projects' operation from the tributary's confluence with the Columbia River to the estuary.

The projects described here are authorized, funded, or carried out by Reclamation by virtue of Congressional or Secretarial authorizations, Congressional appropriations, and contracts with Reclamation.

This section describes depletions of the mainstem Columbia River due to specific Reclamation irrigation project operations. Table C-2 provides a sum of all depletion data from those irrigation projects. There are three points that reflect the flow in the river after depletions. Those points include Priest Rapids, McNary, and Bonneville Dams. These points were selected because they are points where NMFS has established flow objectives. Flows at the dams came from the Bonneville Power Administration's HYDSIM (Hydrosystem Simulator) model. The depletions are included in the system models through the 2010 Modified Flows report (Bonneville 2011).

Table C-1. Summary of the status of ESA compliance for Reclamation tributary irrigation projects' effects on species within the jurisdiction of USFWS and NMFS

Project	Status of ESA Compliance	Source
Chief Joseph Dam [Irrigation Project]	Completed consultation with USFWS for screen modification in 2001. There is no tributary associated with this project. Mainstem effects were previously analyzed in U.S. Fish and Wildlife Service BiOp 2000; NMFS BiOp 2019.	U.S. Fish and Wildlife Service Biological Opinion (BiOp) 2000 (USFWS 2000) NMFS BiOp 2019 (NMFS 2019).
Crooked River and Deschutes Projects	Completed informal consultation with USFWS in 2004 and formal consultation with NMFS in 2005. Reinitiating consultation because of adult and juvenile fish passage at Pelton Round Butte Dam and flow effect of operational change because of habitat conservation plan (HCP) associated with steelhead reintroduction (with other considerations, for example, for Oregon Spotted Frog). Draft HCP submitted to NMFS and USFWS in October 2019. Reclamation submitted Final Deschutes Basin Project Biological Assessment for reinitiating consultation with NMFS and USFWS on October 4, 2019.	NMFS BiOp for Deschutes River Basin Projects, February 2005. (NMFS 2005) USFWS Letter of Concurrence for Deschutes Basin Projects, February 2004 (USFWS 2004). Final Deschutes Basin Project Biological Assessment sent to USFWS and NMFS on October 4, 2019 (Reclamation 2019a).
The Dalles [Irrigation Project]	There is no tributary associated with this project. Mainstem effects were previously analyzed in U.S. Fish and Wildlife Service BiOp 2000 and NMFS BiOp 2019.	U.S. Fish and Wildlife Service BiOp 2000 (USFWS 2000) NMFS BiOp 2008, 2014 (NMFS 2008, 2014a)
Umatilla Project	Completed ESA consultation with USFWS in 2008. Completed ESA consultation with NMFS in April 2004. Reinitiated formal consultation with NMFS in July 2019.	USFWS BiOp for Umatilla Project, July 2008 (USFWS 2008). NMFS BiOp for Umatilla Project Reinitiated Consultation, July 2019 (NMFS 2019).
Yakima Project	In progress. Biological Assessment sent to NMFS and USFWS in April 2015. Updated Yakima Project Operations and Maintenance (O&M) Biological Assessment Supplements sent to USFWS in October 2018 and to NMFS in January 2019.	Biological Assessment for O&M of the Yakima Project, April 2015 (Reclamation 2015). Yakima Project O&M Biological Assessment Supplements sent to USFWS, October 2018 (Reclamation 2018), and to NMFS, January 2019 (Reclamation 2019b).

Table C-2. Average monthly mainstem depletions due to operations of Reclamation’s non-Federal Columbia River Power System (FCRPS) irrigation projects (cfs^a)

Project ^b	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Columbia River												
Chief Joseph Dam Project depletions ^c	-5	0	0	0	0	0	-10	-70	-150	-180	-130	-30
<i>Sum of effects at Priest Rapids</i>	-5	0	0	0	0	0	-10	-70	-150	-180	-130	-30
Flow at Priest Rapids ^d	71,540	98,860	105,270	125,490	117,720	94,910	111,690	164,500	183,840	146,620	118,780	72,200
<i>Depletions as a percentage of PRS Flows</i>	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.04%	-0.09%	-0.12%	-0.11%	-0.04%
Yakima Project depletions ^e	-900	-990	-950	-820	-970	-1,160	-4,600	-8,170	-6,310	-2,880	-1,180	-1,040
Lower Columbia River												
Umatilla Phase II Pump Exchange depletions	-30	0	0	0	0	-10	-40	-60	-100	-120	-110	-90
<i>Sum of depletions at McNary in cfs</i>	-940	-990	-950	-820	-970	-1,170	-4,650	-8,300	-6,560	-3,200	-1,420	-1,160
Flow at McNary ^d	93,800	125,480	140,310	167,790	169,170	155,170	193,530	267,600	285,700	199,000	150,550	97,710
<i>Depletions as a percentage of MCN Flows</i>	-1%	-1%	-1%	0%	-1%	-1%	-2%	-3%	-2%	-2%	-1%	-1%
Umatilla Phase I Pump Exchange depletions	-40	0	0	0	0	-5	-5	-10	-60	-80	-80	-70
Umatilla Project depletion and return flows ^e	50	40	-15	-60	-130	-200	-300	-220	-100	-70	-40	30
Deschutes, and Crooked River Project depletions ^e	-420	-410	-380	-340	-290	-170	-1,400	-1,570	-1,290	-770	-820	-550
The Dalles Project depletions ^c	-20	0	0	0	0	0	-10	-40	-40	-50	-50	-30
<i>Sum of depletions at Bonneville in cfs</i>	-1,370	-1,360	-1,350	-1,220	-1,390	-1,600	-6,390	-10,140	-8,050	-4,350	-2,410	-1,780
Flow at Bonneville ^d	99,560	136,690	154,940	184,660	187,800	174,120	213,970	281,970	296,980	206,950	157,070	104,500
<i>Cumulative depletions as a percentage of BON flows</i>	-1%	-1%	-1%	-1%	-1%	-1%	-3%	-4%	-3%	-2%	-2%	-2%

^a Negative values imply a flow reduction (depletion) due to Reclamation activities. Natural flow diversions would still occur without Reclamation activities.

^b Sources: Chief Joseph Dam – Reclamation 2016a; Yakima – Reclamation 2016b; Deschutes – Reclamation 2017a; Umatilla – Reclamation 2017b; .

^c Not to be confused with the U.S. Army Corps of Engineers’ (Corps’) CRS projects of the same name.

^d Source: Modeled flows from Bonneville’s 2018 Proposed Action HYDSIM Model.

^e Yakima, Umatilla, Deschutes, and Crooked River projects show depletions at the mouth or confluence with the Columbia River. These depletions include those due to natural flow rights (not Reclamation actions) as well as project operations. Therefore, depletions numbers shown here are higher than would actually be attributed to Reclamation actions. Positive numbers reflect return flows.

Table C-3. Average monthly Columbia River diversions and return flows (in cfs) from the Columbia Basin Project

Project	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Columbia River												
Columbia Basin Project withdrawals at JWKIII	-3,277	-475	-220	-24	-170	-1,709	-8,176	-8,670	-8,872	-10,590	-6,748	-6,556
Return flows at Wanapum ^a	475	80	70	60	60	60	70	70	70	80	100	120
Return flows at Priest Rapids ^a	220	220	180	180	220	230	310	280	220	210	260	360
<i>Sum of depletions at Priest Rapids</i>	-2,582	-175	30	216	110	-1,419	-7,796	-8,320	-8,582	-10,300	-6,388	-6,076
Flow at Priest Rapids^b	71,540	98,860	105,270	125,490	117,720	94,910	111,690	164,500	183,840	146,620	118,780	72,200
<i>Depletions as a percentage of PRS Flows</i>	-4%	0%	0%	0%	0%	-1%	-7%	-5%	-5%	-7%	-5%	-8%
Lower Columbia River												
Return flows at McNary ^a	710	510	390	380	370	460	630	600	640	660	670	740
CBP withdrawals at Blocks 2 and 3 ^a	-10	10	10	10	10	-5	-20	-40	-50	-60	-50	-30
<i>Sum of depletions at McNary in cfs</i>	-1,882	345	425	606	490	-964	-7,186	-7,765	-7,992	-9,700	-5,768	-5,366
Flow at McNary^b	93,800	125,480	140,300	167,790	169,170	155,170	193,530	267,600	285,700	199,000	150,550	97,710
<i>Depletions as a percentage of MCN Flows</i>	-2%	0%	0%	0%	0%	-1%	-4%	-3%	-3%	-5%	-4%	-5%
<i>Sum of depletions at Bonneville in cfs</i>	-1,882	345	425	606	490	-964	-7,186	-7,765	-7,992	-9,700	-5,768	-5,366
Flow at Bonneville^b	99,560	136,690	154,940	184,660	187,800	174,120	213,970	281,970	296,980	206,950	157,070	104,500
<i>Depletions as a percentage of BON flows</i>	-2%	0%	0%	0%	0%	-1%	-3%	-3%	-3%	-5%	-4%	-5%

^a Source: 2010 Modified flows (Bonneville 2011)

^b Source: Modeled flows from Bonneville's 2018 Proposed Action Priest Rapids, McNary, and Bonneville Dams are shown as points of reference because they are locations where NMFS has identified flow objectives.

C.3.1 Chief Joseph Dam Project

C.3.1.1 General Project Description

The Chief Joseph Dam Project occupies lands along the Columbia and Okanogan Rivers in north-central Washington and is not part of Chief Joseph Dam, which the Corps operates. There are four divisions and seven units, five of which result in depletions of the Columbia River. All of the units are separate land areas with independent irrigation systems. The project serves about 16,760 irrigable acres.

The Chelan Division borders the north shore of Lake Chelan at its lower end. It comprises about 6,285 acres of land and delivers about 20,280 acre-feet of water. After return flows, depletions from the river constitute about 14,500 acre-feet.

The Foster Creek Division is near the confluence of the Okanogan River with the Columbia River. It has two units with a total acreage of about 2,907 and delivers about 9,970 acre-feet of water. After return flows, depletions from the river total about 6,500 acre-feet.

The Greater Wenatchee Division, with its three units—Brays Landing, East, and Howard Flat—consists of three separate areas along the Columbia River between Wells Dam and Rock Island Dam. Brays Landing and Howard Flat pump from groundwater. The division serves about 4,560 acres and delivers about 14,630 acre-feet of water. After return flows, depletions from the river total about 9,520 acre-feet.

The Whitestone Coulee Division is in the Spectacle Lake area, west of the Okanogan River near Loomis, between Oroville and Tonasket, Washington. The division serves about 3,009 acres and delivers about 10,120 acre-feet of water. After return flows, depletions from the river amount to about 6,630 acre-feet.

C.3.1.2 Depletion Effects on the Mainstem Columbia River

Facility operation is generally limited to the irrigation season, which begins sometime from about mid-April to mid-May and ends sometime from mid-September to October 1. The average annual depletions for the Chief Joseph Dam Project add up to about 37,150 acre-feet. Effects on the Columbia River mainstem flow from the operation and maintenance of the Chief Joseph Dam Project are summarized in Table C-4.

Table C-4. Description of irrigation depletions (in cfs) from the mainstem Columbia River due to the Chief Joseph Dam Project

Item	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total depletions	-5	0	0	0	0	0	-10	-70	-150	-180	-130	-30

C.3.2 Yakima Project

Consultations on the tributary effects of the Yakima Project are being conducted in a separate tributary consultation. A full description of the project facilities and operations can be found in the April 2015 Biological Assessment for O&M of the Yakima Project (Reclamation 2015) and Reclamation's Yakima

Project Interim Comprehensive Basin Operating Plan (IOP) (Reclamation 2002). The tributary consultation ends at the confluence with the Columbia River and does not include mainstem effects. Mainstem effects are included as part of this CRS action.

C.3.2.1 General Project Description

The Yakima Project provides irrigation water for approximately 465,000 acres. The project operates six storage dams and reservoirs for both FRM and irrigation. Reservoirs include Bumping Lake, Clear Creek Reservoir, Rimrock Lake (Tieton Dam), Cle Elum Lake, Kachess Lake, and Keechelus Lake and have a total active capacity of approximately 1.07 MAF.

C.3.2.2 Depletion Effects on the Mainstem Columbia River

Reclamation’s Yakima Project Interim Comprehensive Operating Plan (IOP; Reclamation 2002) is incorporated by reference. The IOP describes project operations in detail, including water storage and diversion rights in the basin.

The IOP informed the computation of the Modified Flows report (Bonnevill 2011), which provides flows at the mouth of the Yakima River under current operations. Effects on flows at the mouth were estimated using unregulated flows (flows without human impacts) and the modified flows. Depletions include the effects of natural flow rights as well as operations of Reclamation Project, so the federal effect on the mainstem Columbia River flows is overestimated. The 2015 Yakima Project Biological Assessment and subsequent supplements to this biological assessment describe additional modifications to project operations; these changes are within the range of impacts described by the depletion estimates using the Modified Flows Report (Bonnevill 2011). Effects on the Columbia River mainstem flow from the operation and maintenance of the Yakima Project are summarized in Table C-5.

Table C-5. Description of Reclamation’s depletions of the mainstem Columbia River from the Yakima Project (cfs)

Item	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total depletions	-900	-990	-950	-820	-970	-1,160	-4,600	-8,170	-6,310	-2,880	-1,180	-1,040

Note: Depletions include natural flow rights as well as operations of Reclamation projects, so effects are greater than actual Reclamation impacts.

C.3.3 Umatilla Project

C.3.3.1 General Project Description

The original Umatilla Project furnishes a full supply of irrigation water to more than 17,000 acres and a supplemental supply to approximately 22,500 acres. These lands, located in north-central Oregon, are divided into four divisions.

In addition, there are approximately 3,800 acres not included in an irrigation district that are provided either a full or supplemental water supply from McKay Reservoir under individual storage contracts.

Reclamation prepared a biological assessment with an additional supplement (Reclamation 2003a) that fully describes project operations. Consultation with NMFS was completed on the Umatilla Project, with a BiOp dated April 23, 2004 (NMFS 2004). Reclamation prepared an operations plan for the Umatilla Basin Project (Reclamation 2011, 2012b) that describes the project facilities and operations. Reclamation reinitiated consultation with NMFS on the operation of the Umatilla Project, because the April 23, 2004, BiOp was only issued for a 10-year duration.

Reclamation prepared a new Biological Assessment for the Umatilla Project and requested re-initiation of consultation on September 15, 2016 (Reclamation 2016c). Reclamation received a non-jeopardy BiOp from NMFS on July 2, 2019. The consultation includes mainstem effects, but only for a short reach of the Columbia River from McNary Dam, where the Phase II pumping facility water intake is located, to where the Umatilla River confluence with the Columbia River. These BiOps do not include mainstem effects downstream of the Umatilla confluence with the Columbia River. Mainstem effects are included as part of this CRS action.

C.3.3.2 Depletion Effects on the Mainstem Columbia River

The mainstem depletions of the Umatilla Project include the tributary operations and Phase I and Phase II water exchange facilities that deliver water directly from the Columbia River (from Lake Wallula behind McNary Dam). Effects on the Columbia River mainstem flow from the operation and maintenance of the Umatilla Project are summarized in Table C-6.

Table C-6. Description of irrigation diversions and return-flow impacts on the mainstem from the Umatilla Project

Item	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Phase II	-30	0	0	0	0	-10	-40	-60	-100	-120	-110	-90
Phase I	-40	0	0	0	0	-5	-5	-10	-60	-80	-80	-70
Umatilla River	50	40	-15	-60	-130	-200	-300	-220	-100	-70	-40	30
Total Mainstem Effect	-20	40	-15	-60	-130	-215	-345	-290	-260	-270	-230	-130

Note: Depletions include those for natural flow rights, so effects are greater than impacts due just to project operations. Positive numbers reflect return flows.

C.3.4 Deschutes River

Tributary consultation for the Deschutes River included two Reclamation projects, including the Crooked River and Deschutes projects (Table C-7; Reclamation 2019a).

C.3.4.1 General Project Description

The Deschutes Project is located near Madras, Oregon. The project provides a full water supply to about 50,000 irrigable acres and a supplemental water supply for about 48,000 irrigable acres. Reservoirs include Wickiup Reservoir, Haystack Reservoir, and Crane Prairie Reservoir, with a total active storage of about 260,900 acre-feet on the upper Deschutes, and Prineville and Ochoco with an additional 111,100

acre-feet on the Crooked River. Reclamation prepared an operations report (Reclamation 2003a) and biological assessment (Reclamation 2003b) that describe in detail the authorizations, facilities, operations, and maintenance activities associated with the Deschutes Project. These documents are incorporated by reference. An HCP on the operations in the Deschutes River is currently being developed, and a Draft HCP document was submitted to the USFWS and NMFS in October 2019. In addition, Reclamation has reinitiated consultation with the USFWS and NMFS because of the operational changes in the Deschutes Project resulting from HCP development. Reclamation submitted a Final Deschutes Project Biological Assessment to NMFS and the USFWS on October 4, 2019. The tributary consultation ends at the Deschutes River’s confluence with the Columbia River and does not include mainstem effects. Mainstem effects are included as part of this CRS action.

C.3.4.2 Deschutes Project

Table C-7. Description of mainstem flow effects from the Crooked River and Deschutes Projects

Item	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Total Depletions	-420	-410	-380	-340	-290	-170	-1,400	-1,570	-1,290	-770	-820	-550

Note: Depletions include natural flow rights in addition to operations of the project, so effects are greater than actual impacts because of Reclamation actions.

C.3.5 The Dalles Project

C.3.5.1 General Project Description

The Dalles Project, Western Division, is on the south side of the Columbia River adjacent to The Dalles, Oregon, about 80 miles east of Portland, Oregon. The Dalles Project is not part of The Dalles Dam, which the Corps operates. The Dalles Project pumps directly from the Bonneville Dam forebay. Although the project includes about 6,000 irrigable acres, water from the Columbia River is supplied to an annual average of 5,600 acres that produce fruit, primarily sweet cherries.

C.3.5.2 Water Supply

Mill Creek Pumping Plant, on the Columbia River about 4 miles downstream from The Dalles Dam, consists of five pump units with a total capacity of 54.2 cfs, as originally constructed. Anadromous fish screens at the intakes of the pumps meet NMFS fish protective criteria. The water supply for The Dalles Project is the Columbia River.

C.3.5.3 Depletion Effects on the Mainstem Columbia River

The Dalles Irrigation District operates and maintains the facilities of The Dalles Project. About 14,000 acre-feet are pumped annually during the irrigation season, March 1 to October 31. Effects on the Columbia River mainstem flow from the operation and maintenance of The Dalles Project are summarized in Table C-8.

Table C-8. Description of irrigation diversions and return-flow impacts on the mainstem from The Dalles Project

Item	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Depletions	-20	0	0	0	0	0	-10	-40	-40	-50	-50	-30

Table C-9 below summarizes the cumulative hydrologic depletions from the Columbia Basin Project and the six other non-CRS Reclamation projects at three points on the Columbia River.

C.4 PROJECTS INCLUDED IN THE 2008 FCRPS BIOP BUT REMOVED BECAUSE THEY HAVE COMPLETED SEPARATE CONSULTATIONS AND HAVE NO EFFECT ON THE MAINSTEM COLUMBIA RIVER

C.4.1 Tualatin Project

The effects on the mainstem Columbia River due to operation of the Tualatin Project were included in past FCRPS BiOps. Since then, Reclamation completed a consultation on operations of the Tualatin Project with NMFS in 2014. Operations of the Tualatin Project were considered to have unmeasurable flow impacts in the Willamette River as well as to the Columbia River in the NMFS 2014 Tualatin Project BiOp (NMFS 2014b). For that reason, Reclamation’s Columbia River flow effects from future operation of the Tualatin Project have been removed from this consultation.

C.4.2 Wapinitia Project

The effects on the mainstem Columbia River due to the operations of the Wapinitia Project in the Deschutes River basin were included in past FCRPS BiOps. An HCP on the operations in the Deschutes River is currently being developed, and a Draft HCP document was submitted to the USFWS and NMFS in October 2019. In addition, Reclamation has reinitiated consultation with the USFWS and NMFS because of the operational changes resulting from HCP development. That reconsultation has fully analyzed the effects of operating the Wapinitia Project and has determined that operational effects of this project are small enough that effects of operations are unmeasurable in the Deschutes River, and therefore are unmeasurable in the Columbia River. For that reason, Reclamation’s Columbia River flow effects from future operation of the Wapinitia Project have been removed from this consultation.

C.4.3 Okanogan Project

The mainstem effects on the Columbia River from operation of the Okanogan Project were included in previous FCRPS BiOps. Reclamation is currently conducting separate consultation of the Okanogan Project. That consultation will include all impacts from the operation of the Okanogan Project, including Okanogan River flow depletions and their effects on Columbia River flows. Because the flow depletions of the Okanogan and Columbia Rivers from the Okanogan Project are small, these impacts are anticipated to be extremely small or unmeasurable in the Columbia River. For that reason, Reclamation’s Columbia River flow effects from future operation of the Okanogan Project have been removed from this consultation.

Table C-9. Monthly average total hydrologic effects (depletions) on the Columbia River (in cfs) due to the CBP and specific Reclamation projects

Project	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Upper Columbia River												
<i>Sum of effects at Priest Rapids</i>	-2,475	-120	50	210	120	-1,200	-6,710	-7,210	-7,500	-9,010	-5,600	-5,880
Flow at Priest Rapids^a	72,390	95,750	105,660	122,170	110,100	101,740	119,820	163,240	172,040	153,390	120,340	73,900
<i>Effects as a percentage of PRS Flows</i>	-3%	0%	0%	0%	0%	-1%	-6%	-4%	-4%	-6%	-5%	-8%
Lower Columbia River												
<i>Sum of effects at McNary in cfs</i>	-2,705	-590	-500	-220	-470	-19,150	-10,740	-14,880	-13,320	-11,410	-6,270	-6,300
Flow at McNary^a	96,780	121,670	141,710	164,530	160,370	161,560	201,350	267,140	273,990	205,870	152,210	97,960
<i>Effects as a percentage of MCN Flows</i>	-3%	0%	0%	0%	0%	-1%	-5%	-6%	-5%	-6%	-4%	-6%
<i>Sum of effects at Bonneville in cfs</i>	-3,135	-960	-895	-620	-890	-2,290	-12,455	-16,720	-14,810	-12,380	-7,260	-6,920
Flow at Bonneville^a	102,560	132,890	156,340	181,400	178,990	180,520	221,750	281,570	282,270	213,820	158,740	104,720
<i>Effects as a percentage of BON flows</i>	-3%	0%	0%	0%	0%	-1%	-6%	-6%	-5%	-6%	-5%	-7%

^a Source: Modeled flows from Bonneville's 2018 proposed final rate case, which includes the 2008 BiOp (NMFS 2008) and the 2010 and 2014 Supplemental BiOps (NMFS 2010, 2014a).

C.5 REFERENCES

- Bonneville 2011. 2010 Level Modified Streamflow. DOE/BP-4352, Bonneville Power Administration, U.S. Department of Energy, Portland, OR. Accessed at <https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/streamflow/2010-Level-Modified-Streamflow.pdf>.
- NMFS (National Marine Fisheries Service). 2004. Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Ongoing Operation of the Umatilla Project and the Umatilla Basin Project. National Marine Fisheries Service, Portland, Oregon, April 23, 2004.
- NMFS (National Marine Fisheries Service). 2005. Endangered Species Act - Section 7 Consultation, Biological Opinion & Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Ongoing Operation and Maintenance of the Deschutes River Basin Projects. National Marine Fisheries Service, Portland, Oregon, February 17, 2005.
- NMFS (National Marine Fisheries Service). 2008. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: 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)(1)(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)). NMFS, Portland, Oregon, 5/5/2008.
- NMFS (National Marine Fisheries Service). 2010. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System (FCRPS), 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program, F/NWR/2010/02096, 5/20/2010.
- NMFS (National Marine Fisheries Service). 2014a. Endangered Species Act - Section 7(a)(2) Consultation, Supplemental Biological Opinion. Consultation on remand for operation of the Federal Columbia River Power System. National Marine Fisheries Service, Portland, Oregon, January 17, 2014.
- NMFS (National Marine Fisheries Service). 2014b. Endangered Species Act Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Operation and Maintenance of the Tualatin Project Scoggins Creek (HUC 1709001003), near Gaston, Washington County, Oregon, October 1, 2014.
- NMFS (National Marine Fisheries Service). 2019. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on Operation and Maintenance of the Umatilla Project and Umatilla Basin Project, Umatilla County, Oregon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, West Coast Region, Portland, Oregon. 66 pp.
- Reclamation 2002. Interim Comprehensive Basin Operating Plan for the Yakima Project Washington. U.S. Bureau of Reclamation, Columbia Cascades Area Office, Yakima, Washington. Accessed at <https://www.usbr.gov/pn/programs/yrbwep/reports/operatingplan/finaliop.pdf>.

Reclamation 2003a. Supplement to the August 2001 Biological Assessment for the Umatilla Project and the Umatilla Basin Project. May 2003. U.S. Bureau of Reclamation Pacific Northwest Region Lower Columbia Area Office Portland, Oregon

Reclamation 2003b. Operations description of the Deschutes River basin projects. Pacific Northwest Region, Boise, Idaho.

Reclamation 2003c. Biological Assessment on continued O&M of the Deschutes River basin projects and effects on essential fish habitat under the Magnuson-Stevens act. Pacific Northwest Region, Boise, Idaho.

Reclamation 2011. Umatilla Basin Annual Operating Plan, Part 1 – Project Overview. Umatilla Basin Project, Pacific Northwest Region, Umatilla Field Office, Hermiston, Oregon.

Reclamation 2012a. Odessa Subarea Special Study Final Environmental Impact Statement, U.S. Bureau of Reclamation, Columbia Basin Project, Washington, April 2012 (includes corresponding section 7 ESA consultation). <https://www.usbr.gov/pn/programs/eis/odessa/index.html>.

Reclamation 2012b. Umatilla Basin Annual Operating Plan, Part 2 – Water Operations. U.S. Bureau of Reclamation, Umatilla Basin Project, Pacific Northwest Region, Umatilla Field Office, Hermiston, Oregon.

Reclamation 2015. Biological Assessment on the Operations and Maintenance of the Yakima Project. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Columbia Cascades Area Office, Yakima, Washington. April 2015.

Reclamation 2016a. Chief Joseph Dam Project – Computed by Lori Postlethwait based on records supplied by Amy Rodman. U.S. Bureau of Reclamation, Pacific Northwest Region, Columbia Cascade Area Office, Ephrata Field Office, 2016.

Reclamation 2016b. Yakima Project Mainstem Depletions based on Communication between Lori Postlethwait of the Pacific Northwest Regional Office and Chris Lynch of the U.S. Bureau of Reclamation, Columbia Cascades Area Office, Yakima, Washington.

Reclamation 2016c. Biological Assessment to Reinitiate Consultation on the Continued Operation and Maintenance of the Umatilla Project and Umatilla Basin Project. September 15, 2016. U.S. Bureau of Reclamation, Pacific Northwest Region, Columbia Cascades Area Office, Yakima, Washington.

Reclamation 2017a. Deschutes River basin projects mainstem depletions based on communication between Jennifer Johnson and Lori Postlethwait, 2017. U.S. Bureau of Reclamation.

Reclamation 2017b. Umatilla Project Depletions from the Umatilla River - Communications between Lori Postlethwait of the Pacific Northwest Regional Office and Boris Belchoff 2017. Pacific Northwest Region, Columbia-Cascade Area Office, Umatilla Field Office, U.S. Bureau of Reclamation.

Reclamation 2018. Updated Proposed Action for Reclamation's Yakima Irrigation Project Operations and Maintenance Consultation; USFWS Supplement to the April 2015 Biological Assessment for Yakima Project Operation and Maintenance. Yakima Project, Washington. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Columbia Cascades Area Office, Yakima, Washington. October 2018.

Reclamation 2019a. Biological Assessment to Reinitiate Consultation on the Continued Operations and Maintenance of the Deschutes River Basin Project and Effects to Essential Fish Habitat under the Magnuson-Stevens Act; Deschutes, Crooked, and Wapinitia Projects, Oregon. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Columbia Cascades Area Office, Yakima, Washington.

Reclamation 2019b. Updated Proposed Action for Reclamation's Yakima Irrigation Project Operations and Maintenance Consultation; NMFS Supplement to the April 2015 Biological Assessment for Yakima Project Operation and Maintenance. Yakima Project, Washington. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Columbia Cascades Area Office, Yakima, Washington. January 2019.

U.S. Fish and Wildlife Service (USFWS). 2000. Biological Opinion for Effects to Listed Species from Operations of the Federal Columbia River Power System. U.S. Fish and Wildlife Service, Regions 1 and 6.

U.S. Fish and Wildlife Service (USFWS). 2004. Letter of Concurrence for Deschutes Basin Projects, United States Fish and Wildlife Service, Bend Field Office, Oregon. May 28, 2004.

U.S. Fish and Wildlife Service (USFWS). 2008. Biological Opinion on the Continued Operation and Maintenance of the Bureau of Reclamation Umatilla/Umatilla Basin Projects and Bonneville Power Administration - funded Fish Passage and Screening Structures. United States Fish and Wildlife Service, LaGrande Field Office, LaGrande, Oregon. July 2008.

**Consultation Package for
Operations and Maintenance of the
Columbia River System**

APPENDIX D – SUPPLEMENTAL NARRATIVE FOR TRIBUTARY HABITAT ACTIONS

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

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D.1 OVERVIEW

The Action Agencies (U.S. Army Corps of Engineers [Corps], U.S. Bureau of Reclamation [Reclamation], and Bonneville Power Administration [Bonneville]) propose to implement targeted tributary habitat improvements during the period covered under this Proposed Action as offsite mitigation to help address uncertainty related to any residual adverse effects of Columbia River System management on Endangered Species Act (ESA)-listed migrating salmon and steelhead, including uncertainty regarding such effects in the face of climate variability. This appendix provides additional supporting information for the Tributary Habitat Proposed Action (Chapter 2, Section 2.4.1.4).

The Action Agencies annually fund numerous tributary habitat improvement actions throughout the Interior Columbia River Basin (ICRB). Maps depicting the geographic extent of the tributary habitat improvement program can be found in the 2016 Comprehensive Evaluation Section 2, Figure 10 and 11 (Corps et al. 2017). Examples of these types of tributary habitat improvement actions include:

- access
- habitat protection
- habitat complexity
- riparian planting
- flow
- fish screens.

The Action Agencies propose to continue to implement strategically prioritized tributary habitat improvement actions that create biological benefits for ESA-listed anadromous fish. These tributary habitat actions will be implemented in collaboration with local sponsors and use the best scientific data available to develop strategies, priorities, and improvement actions.

D.2 LONG-TERM GOALS AND OBJECTIVES OF THE TRIBUTARY HABITAT IMPROVEMENT PROGRAM

The Tributary Habitat Improvement Program will be implemented in a manner directed at achieving the following long-term goals and objectives:

1. Implement actions that strategically address priority limiting factors to improve population abundance, productivity, spatial structure, and diversity of ESA-listed species.
2. Maintain alignment between Tributary Habitat Improvement Program priorities and recovery plans.
3. Target tributary habitat improvement actions that address priority limiting factors (i.e., key limiting factors for each population), in priority locations, that will provide the greatest benefits.
4. Continue to implement the Tributary Habitat Improvement Program through partnerships with stakeholders and local implementation groups.
5. Use the Tributary Habitat Steering Committee established in the 2019 Biological Opinion (BiOp) (USFWS 2008) for continued regional coordination between Action Agencies and National Marine

Fisheries Service (NMFS) to facilitate information sharing, regional problem solving, and guide long-term planning, prioritization, and implementation of tributary habitat improvement projects.

D.3 ACCOMPLISHMENTS TO DATE

Since initiation of the 2008 BiOp, the Action Agencies have made significant investments in tributary habitat conservation and improvement for the benefit of ESA-listed salmon and steelhead. The actions have increased in scope, biological rigor, and collaborative review. From 2005 to 2018, the Action Agencies implemented substantial habitat improvement actions throughout the Columbia River Basin (Table D.1). During the period covered by this Proposed Action, the Action Agencies will implement similar actions based upon the best scientific data available in collaboration with tribes, states, and other local and regional experts. The Action Agencies will implement tributary habitat improvement actions identified and prioritized using science-based approaches that have been and will continue to be refined through research, evolution, adaptive management, and continually improving technology. The basic work process formula is based on the following fundamental steps: assessing habitat conditions, identifying key limiting factors, and working toward ameliorating those limiting conditions (Table D.1).

D.4 EVOLUTION OF THE PROGRAM

As shown in Table D.1, the Action Agencies have achieved significant accomplishments over the last 13 years of the program (2005–2018). These accomplishments, along with improvements in data management; long-term research, monitoring, and evaluation (RM&E) data; improved technology; and the general maturation of the habitat program have informed and improved our ability to more effectively guide our Tributary Habitat Improvement Program. The current habitat Proposed Action reflects these advances in program management.

An example of this effort is the Lemhi Subbasin, which, in the mid-1990s at the time of the first ESA listing, had more than 70 barriers on the mainstem of the river that were at least partial barriers to juvenile and adult fish movement. Along with these access barriers, a significant number of diversions were unscreened or had screens that were out of date. In addition to that, the river was essentially dry in the late summer in the lower few miles below the L-6 diversion and most tributaries of historical significance to anadromous fish were disconnected and dry at key times of the year.

Table D.1. Tributary habitat improvement metrics: Chinook ESUs and Steelhead DPSs, 2007–2018 (Bonneville 2019). The categories acres protected, acres improved, miles of enhanced stream complexity and miles protected also encompass actions directed at reducing sediments and reconnecting floodplains.

Action Type^a	Snake River Spring Chinook Salmon	Upper Columbia Spring Chinook Salmon	Snake River Steelhead	Upper Columbia Steelhead
Acre-feet of Water Protected (Measure 16) <i>(purchasing land, leasing land, or acquiring water)</i>	84,075	23,709	84,565	40,373
Riparian Acres Protected (Measure 82) <i>(by land purchases or conservation easements via purchasing, leasing or fencing land)</i>	3,221	315	3,342	421
Riparian Acres Improved (Measure 83) <i>(to improve riparian habitat, such as enhancing floodplains, removing dikes, planting or restoring wetlands)</i>	6,651	435	7,791	1,610
Miles of enhanced or newly accessible habitat (Measure 10) <i>(by providing passage or removing barriers)</i>	1,301	117	1,364	231
Miles of improved stream complexity (Measure 6) <i>(by adding wood or boulder structures or reconnecting existing habitat, such as side channels)</i>	193	29	215	36
Miles protected (Measure 80) <i>(by land purchases, conservation easements and fencing)</i>	184	10	227	19
Screens installed or addressed (Measure 78) <i>(installing or addressing fish screens or by elimination/consolidation of diversions)</i>	85	12	85	98

Starting in the mid-1990s, local partners began working on these issues with Action Agency funding, among other sources, and the program increased in size with the 2000 and the 2008 BiOps—the increase in action agency resources including funding and technical expertise. At the time of this Proposed Action, all diversions on the mainstem Lemhi and the associated fish screens are in compliance with state and federal criteria for passage and screening—there is a minimum flow of 25 cfs below the L-6 diversion throughout the year, and several key tributaries are now connected and available for use by anadromous fish. In total, tributary reconnection efforts have resulted in an increase of 120 river kilometers available to juveniles and adults since 2009, and an 86 percent increase in fully connected habitat. Because of the success in accomplishing the above actions, new efforts in the Lemhi Basin will

focus on increasing the juvenile carrying capacity and generally work to improve habitat quality and quantity as outlined in the Integrated Rehabilitation Assessment (IRA) document (OSC 2019). The IRA estimates that juvenile carrying capacity in the Lemhi River is at 30 percent of that required to meet recovery targets. Future MRA documents will describe target habitat conditions and provide guidance for project implementation.

Similarly, habitat improvement goals within the Pahsimeroi River Basin have focused on removing barriers, increasing instream flow, and screening irrigation diversions. These actions effectively doubled the amount of spawning and rearing habitat available to salmon and steelhead, resulting in an increase in juvenile Chinook salmon survival and productivity. Some of the findings reported by Copeland (2018) included the following:

- greatly increased spawning distribution
- parr using new habitat
- increased numbers of juveniles from river
- increased emigrants/female.

Figure D-1 demonstrates the biological response to restoring longitudinal connectivity in a system through barrier removal and flow acquisition (from Copeland 2018).

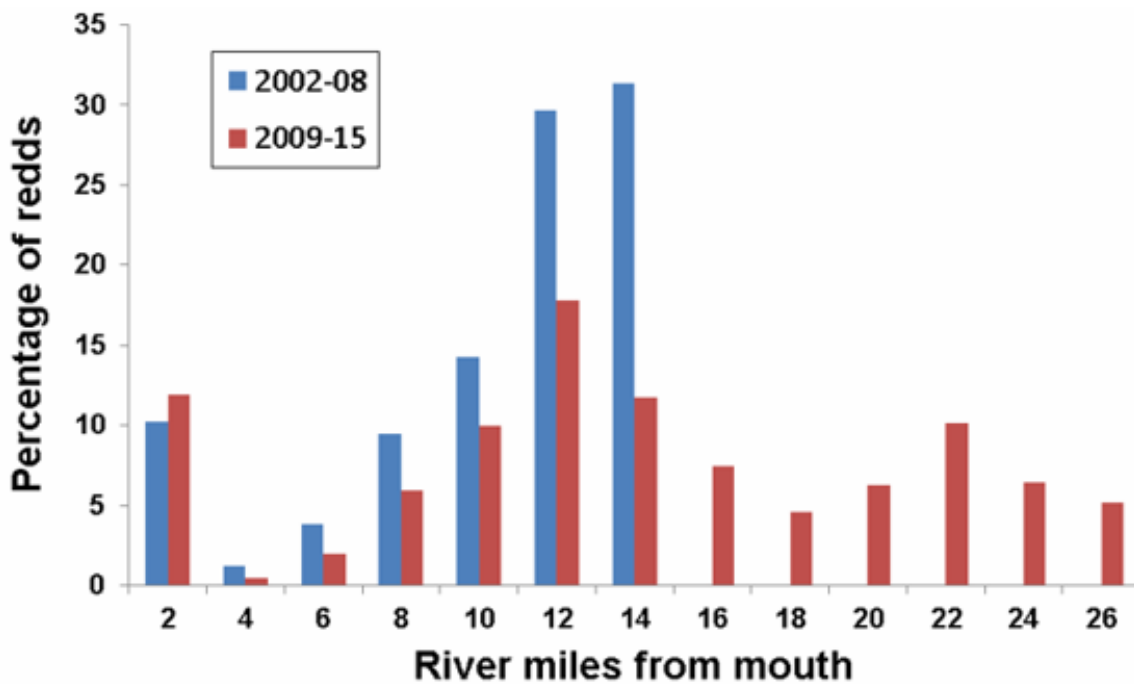


Figure D-1. Data presented by Copeland 2018 on increase of Chinook salmon redd densities and distribution after making longitudinal connectivity (passage and flow) improvements within the Pahsimeroi River

The Southern Cross project in the Grande Ronde River Basin is the result of a multi-year – multi-phase – multi-partner restoration program conducted to benefit the Catherine Creek Chinook population. This

project represents a comprehensive approach to floodplain restoration and channel construction to directly address priority limiting factors affecting juvenile rearing, adult spawning, and holding habitat for both Chinook salmon and steelhead. The project location was identified through the Grande Ronde Atlas Process as the core production area and top priority for Chinook salmon. Some key CC-44 Southern Cross metrics are:

- 4,200 linear feet of new main channel (including four confluences the existing channel).
- 955 linear feet of perennial side channel.
- 425 linear feet of new ephemeral side channel.
- 1,425 linear feet of alcoves and spring channels.
- 15 engineered riffles in reconstructed Catherine Creek channel.
- 142 main channel wood structures (pool, riffles, glides and runs).

The Southern Cross Ranch was purchased through the Bonneville acquisition program in cooperation with the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) to secure this critical area and implement restoration actions. In addition, flow acquisition and fish passage improvements were implemented to improve longitudinal connectivity through the consolidation of four irrigation diversions with attendant irrigation water management actions to reduce seepage losses and improve irrigation. The project is an excellent example of the “protect – restore” methodology of implementing habitat improvement conservation strategies. Figure D-2 provides information about the biological response of the project (CTUIR 2017).

Similar stories are repeated throughout the interior Columbia Basin in many key tributaries. Unlike passage barriers in tributary mainstems, which must all be ultimately addressed, the habitat improvements must be prioritized based on many factors and the benefits of proposed projects must be understood. Tools for this analysis are evolving and being applied throughout the basin but include the Atlas Process in the Grande Ronde River Basin, the IRA/MRA process in the upper Salmon River Basin, and others along with data from the RM&E programs, including juvenile fish tracking studies used to describe preferred habitat conditions and fish use. This information helps target actions to the right area and right type of work.

The Action Agencies’ implementation of tributary habitat actions has matured significantly over the past decade. This has led to improved planning, prioritization, selection, design, and implementation of habitat improvement actions, which in turn have benefited listed salmonids by increasing their abundance, distribution, and growth (Hillman et al. 2016, pg. ES-3).

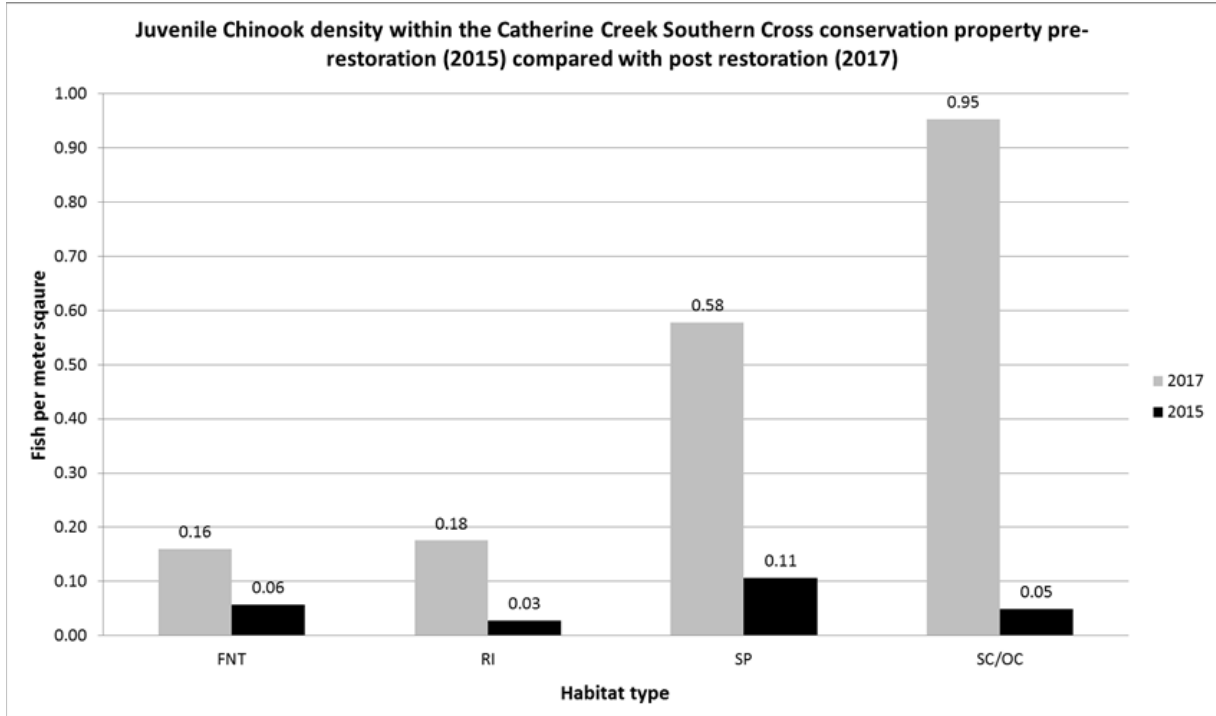


Figure D-2. Biological response in fish abundance as measured by pre- and post-project conditions at the CC44 Southern Cross Floodplain Habitat Improvement Project (CTUIR 2017)

The proposals that will most influence the continued evolution of the Tributary Habitat Improvement Program under this Proposed Action include the following:

1. Creation of the Tributary Habitat Steering Committee (Section D.5.1) and the Science Committee (Section D.5.2), which enable effective and responsive adaptive management.
2. Continued improvement of and reliance on subbasin planning and prioritization documents such as Atlas and IRA.
3. Continued adjustments in the RM&E program to more directly inform the habitat implementation program.
4. Increased ability of databases to inform implementation, report metrics, and allow easier transfer of information.

D.5 PROPOSED PROGRAM STRUCTURE

The Tributary Habitat Improvement Program will be implemented using the implementation structure depicted in Figure D-3.

D.5.1 Salmon and Steelhead Tributary Habitat Program Steering Committee

The Action Agencies have formalized the Tributary Habitat Steering Committee (THSC), which was established as a requirement of the 2019 BiOp. The THSC will include representatives from NMFS, Reclamation, and Bonneville. The THSC’s role is as follows:

- Oversee and guide implementation of the Columbia River System (CRS) BiOp Tributary Habitat Improvement Program in a manner that achieves the goals and objectives of the program.
- Ensure effective and regular communication between NMFS, Bonneville, and Reclamation on the Action Agencies' Tributary Habitat Improvement Program.
- Develop guidance and methods to strategically implement the Tributary Habitat Improvement Program, including prioritizing major population groups (MPGs) and populations and consistent action prioritization within subbasins.
- Coordinate with the Tributary Habitat RM&E program to support THSC needs.
- Establish a science committee that will inform the THSC as described in the following sections.
- Develop an adaptive management framework for the program so that new science and learning can be effectively applied.
- Continue to support partnerships with stakeholders and local implementing groups and continue coordination between implementers and technical experts.

D.5.2 Science Committee

The science committee will provide input and review of technical documents related to implementing the Tributary Habitat Improvement Program consistent with the best available science and in a manner directed at achieving the goals of the program (see above). The specific operating rules, charter, membership, and time requirements for this team will be established by the THSC and approved by Bonneville, NMFS, and the Bureau of Reclamation within the first year of implementing this Proposed Action. General functions of the team will include the following:

- Provide science-based guidance to the THSC to support implementation of the Tributary Habitat Improvement Program to ensure that the program's goals and objectives are achieved.
- Establish a framework of "best practices" based on existing literature and contemporary, applicable examples (e.g., Puget Sound), and articulate guiding principles for habitat improvement programs.
- Make science-based recommendations that integrate regionally applicable science.
- Provide quality assurance and guidance regarding local processes used to identify and prioritize actions to ensure that they are technically sound and consistent with best practices.

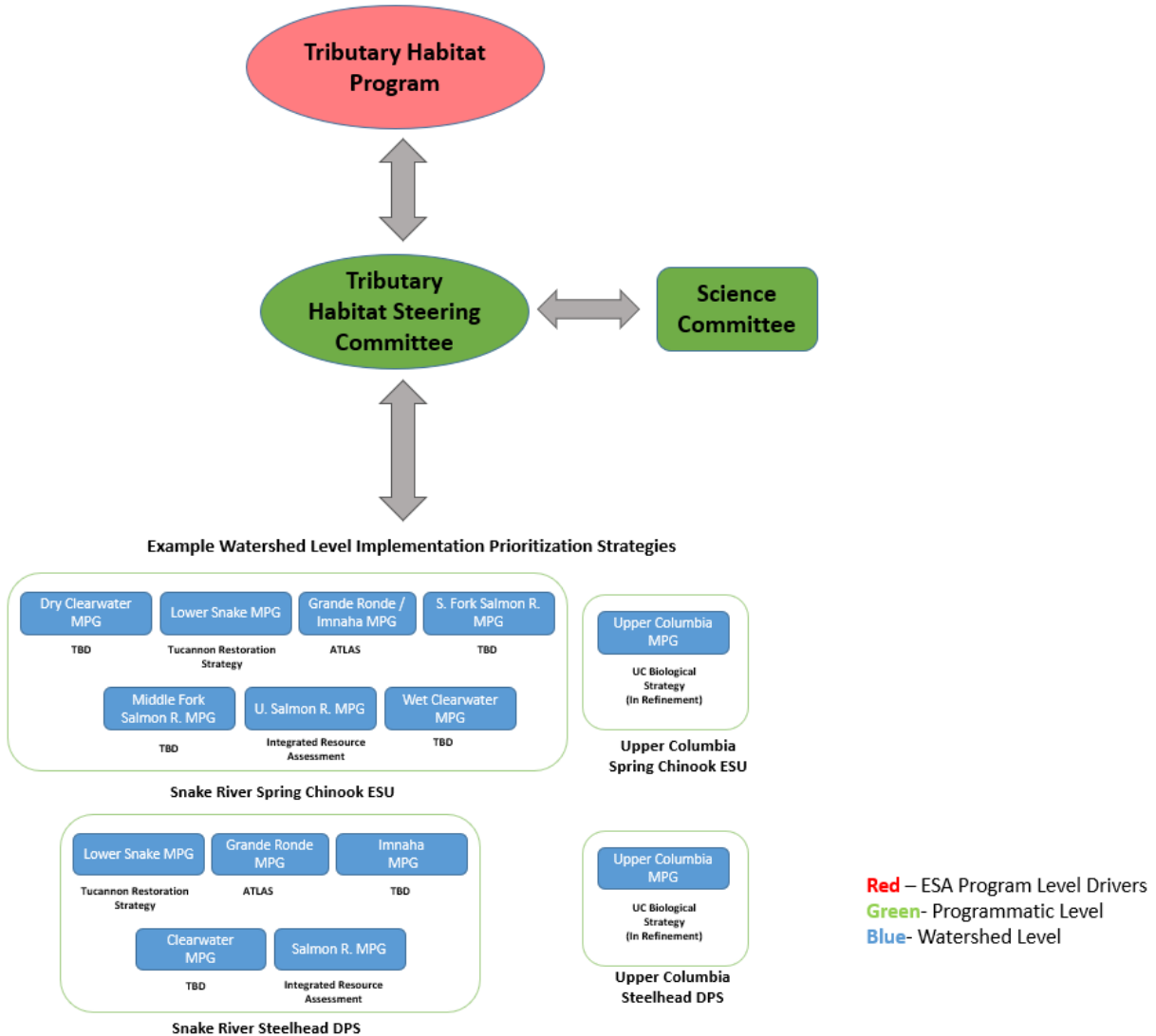


Figure D-3. Tributary Habitat Improvement Program implementation structure

D.5.3 Local Implementation Groups

The Action Agencies will continue to support and work with local implementation groups in the various subbasins in the interior Columbia Basin including states, tribes, nongovernmental organizations, local governments, soil and water conservation districts, and others. The program model uses local implementors and coordinating entities such as the Grande Ronde Model Watershed that act as the lead for local planning processes including the prioritization of actions in each basin. The THSC will provide information for potential use by local entities.

Local implementation groups engage in planning efforts as well as field level monitoring efforts. There are several good examples of localized efforts that provide a comprehensive analysis of an MPG or subbasin and anchor the development of a project selection and prioritization process. Examples of these recent efforts include the Atlas Process in the Grande Ronde and Wallowa River Basins, the IRA/MRA process in the upper Salmon River, and the Biological Strategy in the upper Columbia River.

D.6 PRIORITIES

An important aspect of implementation of the Tributary Habitat Improvement Program is identification of which populations will be the focus of implementation. The basis for determining population priorities will include (1) the extent to which they are impacted by the operations of the CRS, (2) the principles regarding “focal populations” laid out in Cooney (in press),¹ (3) where applicable, ESA recovery plan documents, and (4) additional regional and local planning and prioritization documents including Atlas, the IRA/MRA, and others. Population (and to some extent, MPG) priorities will be evaluated periodically by the THSC and the Science Committee based on new information, such as NMFS 5-year Status Reviews, to ensure that they remain appropriate.

Initially (i.e., for the first 5-year period of this Proposed Action), the Action Agencies intend to focus on Snake River spring Chinook and upper Columbia spring Chinook. These actions will also have benefits for the overlaying steelhead distinct population segments (DPSs). Significant habitat work will occur on other ESA-listed populations as well such as Mid-Columbia steelhead. However, key populations associated with the above-mentioned species will be priorities at the start of the first 5-year BiOp period. In general, these populations are consistent with those identified as “priority populations” in the 2008 BiOp (USFWS 2008), and they are consistent with the focal population analysis for Snake River spring/summer Chinook salmon that is documented by Cooney (in press), and with priorities identified through local processes such as the IRA/MRA and Atlas.

These priorities will be revisited on a regular basis (most thoroughly at 5-year intervals) by the THSC and science committee to ensure that the Tributary Habitat Improvement Program is focusing efforts where the greatest benefits to both near-term improvements and long-term recovery can be achieved. Information and accomplishments will be analyzed by the THSC with support from the science committee, in addition to input from RME team and local implementers. Changes to priorities will be made as appropriate.

D.7 PROPOSED ACTIONS AND METRICS

For the period covered by this consultation, the Action Agencies will implement a Tributary Habitat Improvement Program. The effort will be implemented at a level similar to that of the 2019 BiOp and will focus on priority populations determined by the THSC based on the information and considerations described in Section D.6. Two metrics tables (Table D.2 and Table D.3) are provided below. The first table covers the proposed program metrics for the initial 5-year period of the BiOp (2021–2026) and the second table provides projected estimates of program metrics covering the 15-year duration of the BiOp (2021–2036).

¹ 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 (in press).

The 2008 BiOp initiated habitat complexity as a metric in addition to screens, access, and flow, which carried over from previous BiOps. This soon led to initiation of tributary and reach assessments in key basins and other planning efforts to determine requirements and priorities for habitat work. From 2010 through 2015, assessments were completed in most key basins and they guided initial habitat work. The number of fish screen and access projects began to drop because most were completed, and as habitat assessments and projects were developed. Habitat action design capability increased at a rapid rate as resources expanded to fit the need. After 2016, larger more multidisciplinary planning efforts were completed in key basins led by the Atlas Process in the Grande Ronde River Basin (2014) and the IRA/MRA process in the upper Salmon River Basin (IRA 2019). Partly as a result of these large planning efforts, significant Action Agency funding, and advancements in scientific knowledge and capability, the habitat projects being completed today are much more complex and dynamic. A general summary of the status of each major project type follows:

- Fish screens – Fish screen installation in key basins has transitioned from an implementation program to a maintenance program. There are a few small screens on minor tributaries that may be built.
- Barriers – Barriers in key basins have transitioned from an implementation program to a maintenance program. There are a few small barriers on tributaries that may be removed or reconstructed.
- Flow – Flows, in general, have improved over the last 20 years in key areas of the focal population basins. There are still priority reaches that would benefit from flow augmentation at key times of the year (usually late summer low flows). Flow acquisition is expected to be more strategic and targeted in the 2020 BiOp than in previous BiOps.
- Habitat complexity – Habitat complexity will be the primary effort of the Action Agencies in the 2020 BiOp, which will focus on larger, connected, highly complex projects that focus on increasing the diversity of habitats at all life stages. New science allows efforts to enhance habitat complexity to be more strategic and targeted, and there is new technology available to prioritize habitat efforts.

The tributary habitat program will be strategically implemented and resources directed towards species based on recovery priority and collective impacts of the hydro system. For lower river stocks including the Middle Columbia DPS, habitat improvement investments will continue as a component of BPA's Fish and Wildlife program. However, Snake River and Upper Columbia listed Chinook and Steelhead will be the prioritized focus for consideration in this ESA consultation. Adaptive management of population (and to some extent, MPG) priorities will be evaluated periodically by the THSC and the Science Committee to ensure they remain appropriate.

Similarly, for those lower Columbia evolutionarily significant units (ESUs)/DPSs that have been affected by CRS management (specific populations of Columbia River chum, and lower Columbia River Coho, Chinook, and steelhead), the Action Agencies will provide funding and/or technical assistance for habitat improvement actions consistent with recovery plan implementation priorities and other regional efforts, as funding allows.

Table D.2. Proposed habitat metrics (2021–2026) for major population groups in the Snake River and upper Columbia spring/summer Chinook evolutionarily significant unit (ESU) and Snake River and upper Columbia steelhead DPS and the middle Columbia steelhead DPS

Major Population Group	Flow Protected (cfs)	Flow Enhanced (acre-feet)	Entrainment Screening (# screens)	Habitat Access (miles)	Stream Complexity (miles)	Riparian Habitat Improved (acres)
Snake River spring/summer Chinook major population groups						
Grande Ronde / Imnaha	79	6893	0	49	8	140
Upper Salmon	76	9680	24	16	6	36
Lower Snake	0	0	0	3	10	156
Upper Columbia River spring Chinook ESU						
Upper Columbia/ East Slope Cascades	29	5309	5	5	8	68
Snake River steelhead DPS major population groups						
Grande Ronde	79	6893	0	54	10	356
Clearwater	0	0	0	17	6	419
Salmon	76	6360	25	30	6	326
Lower Snake	0	0	0	3	10	116
Upper Columbia River steelhead DPS						
Upper Columbia/ East Slope Cascades	42	8254	10	35	9	109

Table D.3. Projected estimates of habitat metrics (2021–2036) for major population groups in the Snake River and upper Columbia spring/summer Chinook evolutionarily significant unit (ESU) and Snake River and upper Columbia steelhead DPS and the middle Columbia steelhead DPS

Major Population Group	Flow Protected (CFS)	Flow Enhanced (acre-feet)	Entrainment Screening (# screens)	Habitat Access (miles)	Stream Complexity (miles)	Riparian Habitat Improved (acres)
Snake River spring/summer Chinook major population groups						
Grande Ronde / Imnaha	178	15509	0	87	24	420
Upper Salmon	171	21779	36	30	18	107
Lower Snake	0	0	0	6	29	468

Major Population Group	Flow Protected (CFS)	Flow Enhanced (acre-feet)	Entrainment Screening (# screens)	Habitat Access (miles)	Stream Complexity (miles)	Riparian Habitat Improved (acres)
Upper Columbia River Spring Chinook ESU						
Upper Columbia / East Slope Cascades	64	11946	8	9	25	205
Snake River steelhead DPS major population groups						
Grande Ronde	178	15509	0	96	30	1069
Clearwater	0	0	0	31	16	1258
Salmon	170	14309	38	54	19	979
Lower Snake	0	0	0	6	29	349
Upper Columbia River Steelhead DPS						
Upper Columbia / East Slope Cascades	95	18571	15	62	26	328

D.8 IMPLEMENTATION PROCESS AND PRIORITIZATION

The Action Agencies propose the following hierarchical process as a structured approach to implementation of tributary habitat improvements, as shown in Figure D-4. The model uses a tiered approach that considers the identification of key major population groups—populations targeted by NMFS for recovery priorities (Cooney in press)—balanced against the collective impacts of the hydro system impacts on salmon and steelhead and these species’ ability to negotiate the river system to reach natal streams and spawning grounds. At the implementation level, continued development of strategic plans where needed and adaptive management where they currently exist will be used to guide implementation. Action-specific quality assurance will be used, thereby leveraging existing systems (e.g., Habitat Improvement Program [HIP] programmatic BiOp for Bonneville-funded actions).

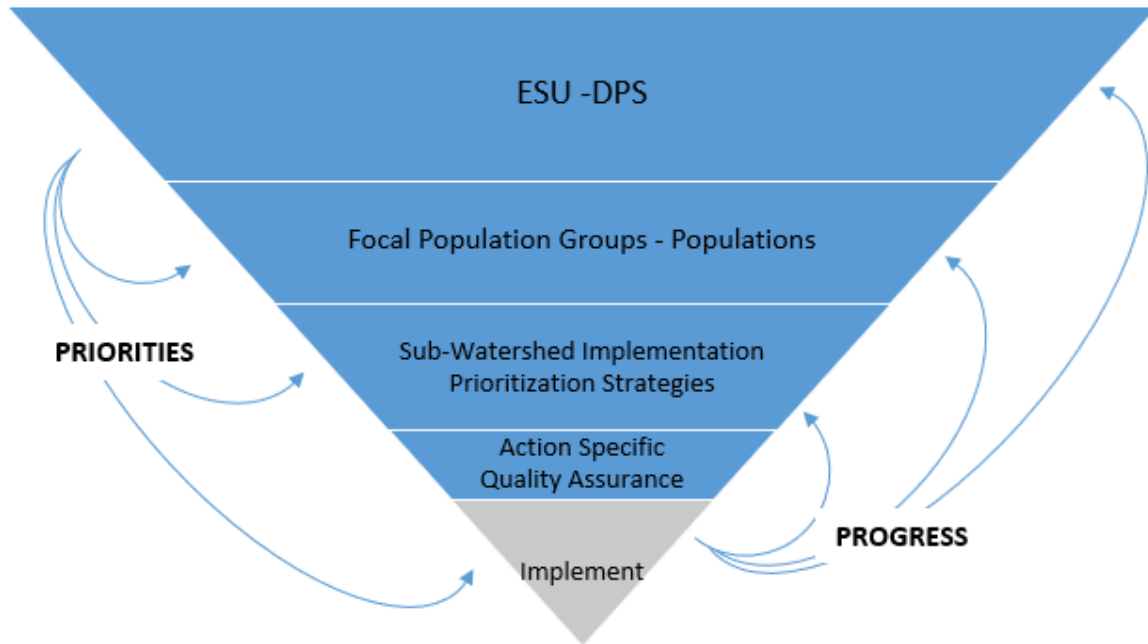


Figure D-4. Proposed process for implementation of tributary habitat improvements

The Action Agencies have been collaboratively working with local partners within priority basins to complete subbasin planning and prioritization efforts. This has been achieved by developing limiting factors-based implementation strategies that align with ESA recovery plans, Northwest Power and Conservation Council (NPCC) subbasin plans, and existing local plans. These efforts use scientific data, research, and local field knowledge to create a strategic, integrated, collaborative, and prioritized habitat local field implementation plan. Basin partners come together as a unified group to apply a technically sound rationale to identify key areas and reaches within the watershed. The partners work together to target mutually agreed-upon target areas and actions.

The Action Agencies partnered with local entities (e.g., states, tribes, regional technical teams, and salmon recovery boards) and have made progress in developing strategies such as the Atlas effort in the Grand Ronde and Clearwater River Basins and the IRA in the upper Salmon River Basin.

Having an implementation prioritization strategy in place allows the Action Agencies and their partners to adjust these plans as limiting factors and locations shift in priority. Where these strategy documents exist, the Actions Agencies will continue to improve and adapt them to changing priorities. For watersheds that do not currently have strategies in place, the Action Agencies will coordinate with local sponsors in developing these products to improve projects implemented.

The THSC will serve a critical function in the adaptive management of the proposed Implementation process by providing guidance on changes in program priorities and review of and concurrence on basin specific implementation strategies. The THSC will leverage information and guidance from the Science Committee to ensure best practices are used in strategy development revision and to integrate new research and scientific findings into the key levels of the proposed Implementation process. Two key areas that will be components of existing program adaptive management include (1) evaluation of climate change effects on action locations and activity types and (2) limiting factors-based assessments

that link to basin specific evaluations of habitat capacity by species and life history. These criteria are discussed further in the following section. The Action Agencies will approach the implementation of specific restoration actions and climate change effects following recommendations authored by Beechie et al. (2013).

Beechie stated,

we found that restoring floodplain connectivity, restoring streamflow regimes, and re-aggrading incised channels are most likely to ameliorate streamflow and temperature changes and increase habitat diversity and population resilience. By contrast, most restoration actions focused on instream rehabilitation are unlikely to ameliorate climate change effects.

Table D.4 is taken from Beechie’s work to illustrate the relationship between habitat improvement actions and climate change impacts.

Table D.4. General restoration categories and their ability to ameliorate climate change impacts as presented by Beechie et al. (2012). In the Floodplain Connectivity category, the increase low flow cell has been asterisked to acknowledge that floodplain projects can affect low flow considering hydrology, geology, and other environmental variables.

Restoration action	Temperature increase	Low flow decrease	Peak flow increase	Increase resilience
Longitudinal connectivity	Y	Y	N	Y
Floodplain connectivity	Y	N*	Y	Y
Restore incised channel	Y	Y	Y	Y
Restore in-stream flow	Y	Y	N	N/Y
Riparian rehabilitation	Y	N/Y	N	N
Sediment reduction	N	N	N	N
In-stream habitat	N	N	N	N
Nutrient enrichment	N	N	N	N

Life history-based habitat capacity analysis can be used to perform population-based bottleneck analysis and provide a strategic foundation for establishment of near-term restoration prioritization. This approach is described by Roni et al. (2016) as follows: “A critical part of determining appropriate watershed restoration actions for increasing salmon populations is understanding which life stage and habitat are limiting population size (Beechie et al. 2003)” and they further state “the limiting factors approach of Reeves et al. (1989), Beechie et al. (1994), Pollock et al. (2004) and others, which is based on habitat area and capacity, provides a straightforward approach to determining which life stage and habitat are limiting salmon at a population scale.” Identifying the limiting life stage for salmonids is an important component of assessing potential problems that can help identify and prioritize future restoration efforts (Beechie et al. 2010) as well as strategically identifying critical life history bottlenecks (Figure D-5) (Roni et al. 2014).

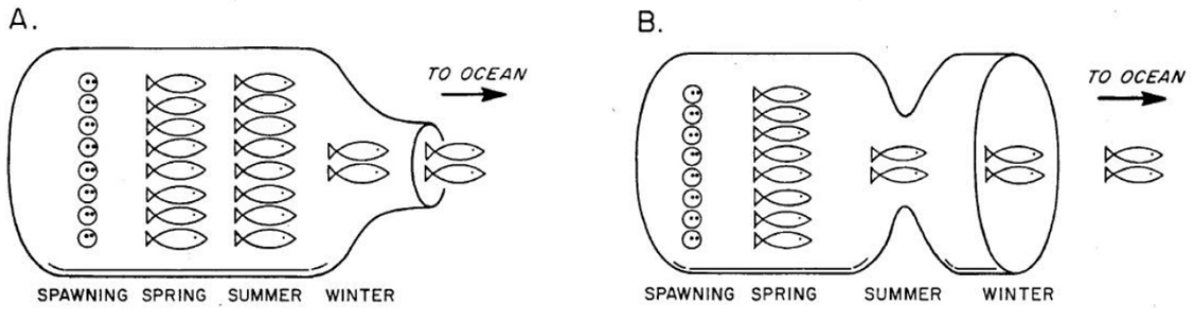


Figure D-5. Examples of habitat bottlenecks occurring during (A) the winter and (B) the summer (ODFW 2003)

Like Roni’s findings above, Beechie and Pess (2014) recommended the following process when determining the production potential of a given watershed:

First, it is important to attempt to quantify habitat area, type, quality, and fish use prior to restoration so changes that do occur can be compared to hypothesized outcomes. Second, it is important to understand the geomorphic potential of a given stream reach because the potential reach morphology helps to determine the types of actions that are suitable for each reach and likely increase in habitat capacity. Lastly, it is important to clearly identify restoration objectives and to develop measurable and quantifiable restoration targets. Without such targets, it is difficult develop specific restoration scenarios that focus on achieving long-term goals, and to ascertain whether restoration actions are successful.

An example of this approach after Zabel (2016) is provided in Figure D-6 below.

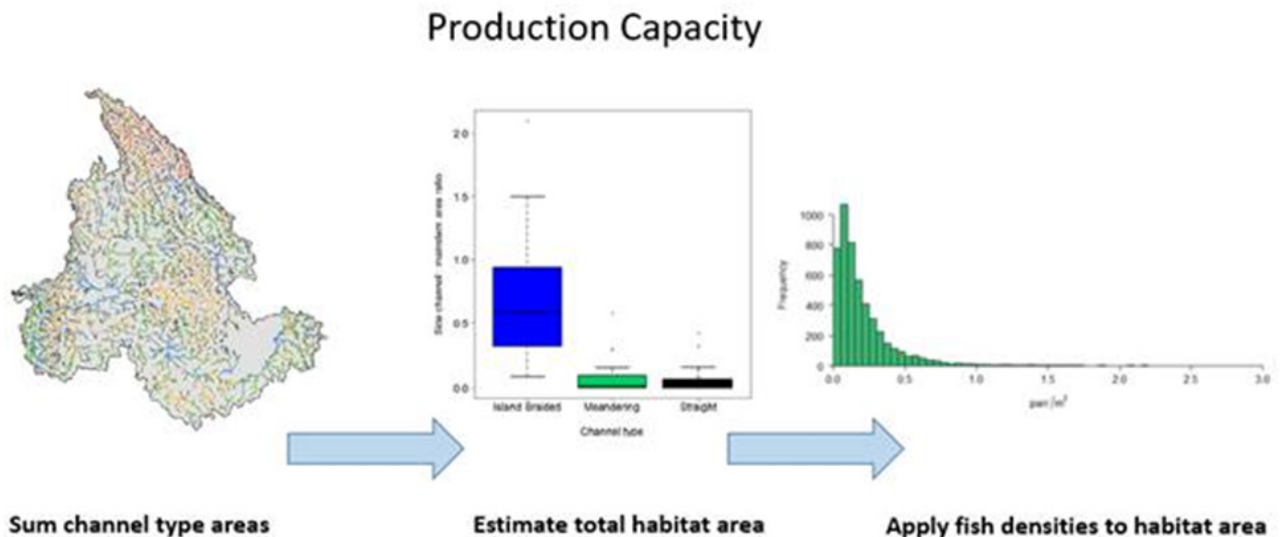


Figure D-6. Assessment of stream habitat (by stream type) as translated to fish abundance by Zabel et. al. (2016)

The Action Agencies will continue to focus restoration actions that leverage the existing body of science and improve habitat conditions by taking strategically focused habitat improvement actions defined by an ongoing commitment to improve and develop strategic plans in the priority basins and by leveraging a habitat capacity-based approach.

D.9 TRIBUTARY HABITAT REPORTING AND EVALUATION

Over the duration of the Proposed Action, the success of the Tributary Habitat Improvement Program will be reviewed regularly and adaptively managed as described in the Adaptive Management/Decision Support section. To facilitate this review and adaptive management, the Action Agencies will develop, in coordination with NMFS, a series of prospective 5-year implementation plans. To guide and inform the 5-year implementation plans, they will also report annually and comprehensively at 5-year intervals, on progress of actions that have been implemented. Accomplishments will be reported for major population groups annually with the assessment of population level accomplishments utilized to inform program adaptive management during 5-year reviews.

Collectively, these reports and plans will provide NMFS with assurances that implementation appears to be consistent with the level of effort in the Proposed Action. In addition, the Action Agencies will provide information sufficient to inform overall assessment of the biological benefits of the program both qualitatively and quantitatively (e.g., through life cycle modeling). These periodic evaluations will be crucial to allow effective adaptive management of the program. They will allow evaluation of prospective benefits of actions using best available information and allow informed decisions about changes in program implementation that would provide enhanced benefits.

Annual and 5-year reporting will aim to improve consistency between basins and reporting of information and sharing of information between entities. The increased availability of high-quality databases by the Action Agencies in conjunction with synchronized annual reporting, improved data management, and other technology will improve the 5-year rollup and enable analysis of metrics to be a more efficient, streamlined, and useful process than previous reporting.

The THSC, in coordination with the Science Committee, will develop the final requirements for both the annual and 5-year rollup and analysis, and will ensure that reporting objectives are met and are useful for the THSC and Science Committee in adaptively managing the Tributary Habitat Improvement Program. Details of the metrics and narrative information reported and the protocols for reporting will be developed by the THSC in coordination with the Science Committee and will be updated periodically.

The THSC, in coordination with the Science Committee, will develop protocols and formats for aggregating the information reported at the action level up to the population, MPG, and ESU/DPS levels and determine appropriate intervals for reporting at these higher levels. Anticipated metrics for reporting at the population, MPG, and ESU/DPS scales, consistent with past reporting, include the following:

- flow protected (cfs)
- flow enhanced (acre-feet)
- entrainment screening (number of screens)

- habitat access (miles of access)
- stream complexity (miles of stream complexity improved)
- riparian habitat improved (miles or acres of riparian habitat enhanced).

The THSC will clarify and update reporting metrics, as needed, to promote consistency and efficiency. The Action Agencies are dedicated to aligning habitat database and system reporting efforts, where feasible. The Action Agencies will work with NMFS, through the THSC and Science Committee, to ensure that processes for quality assurance/quality control of data reported are in place, that a mutually agreed-upon timetable and process for data transfer is developed, and that an adaptive management process is implemented.

D.10 MONITORING AND EVALUATION

The Action Agencies are committed to funding the tributary habitat RM&E described below, as well as engaging in a collaborative process with NMFS, USFWS, Council, Tribes, and regional partners to develop and implement a Columbia River Basin tributary habitat RM&E strategy that will align with and directly support the documentation and effectiveness needs of the THSC and associated science committee. The Action Agencies commenced development of the draft Columbia River Basin tributary habitat RM&E strategy in 2018 and have initiated a regional review process with NMFS, USFWS, Council, Tribes, and regional partners in 2019. After soliciting input and feedback on the draft strategy, the Action Agencies will complete the strategy within 2 years of completion of the 2020 BiOp for anadromous fish species. The anticipated level of take associated with the resulting strategy will be at or below that of the 2008 BiOp for tributary habitat RM&E. The Action Agencies will coordinate with NMFS, USFWS, the THSC, and other regional partners to identify core habitat data objectives, to evaluate the success of the Action Agencies program, and to support adaptive management of the ongoing habitat RM&E program in the forthcoming strategy. Where feasible, the Action Agencies will align habitat RM&E reporting efforts with the THSC reporting and NMFS 5-year species status reviews to maximize the benefits of habitat RM&E in informing on the ground implementation.

The Action Agencies will implement a tributary habitat RM&E program and strategy to assess tributary habitat conditions, limiting factors, habitat-improvement effectiveness, and to address critical uncertainties associated with offsite habitat mitigation actions. Generally, this habitat RM&E program is structured to include compliance, implementation, effectiveness, and status and trends monitoring and research, all prioritized within available Action Agency budgets. The Action Agencies' efforts focus on needs included in this Proposed Action. This work is concurrent to RM&E efforts funded by other federal, state, tribal, utility, and private parties that all contribute to larger basin-wide RM&E data and analyses.

During the development of the habitat RM&E strategy, the Action Agencies will continue to fund tributary habitat RM&E to address interim needs and habitat management applications during this consultation period. This interim habitat RM&E is described by RM&E type below.

D.10.1 Status and trends of habitat and fish

In order to track broad-scale changes in select habitat conditions, Bonneville will support the annual collection of habitat status and trends information, including stream temperature and flow across the Columbia River Basin. Bonneville will explore opportunities for programmatic integration of temperature and flow data within regional data display and modeling efforts such as the U. S. Forest Service (USFS)

NorWeST stream temperature platform. A subset of watersheds within the Snake River, upper Columbia, and mid-Columbia ESUs will continue to implement regional habitat data collection to support existing long-term habitat monitoring efforts. Consistent with the 2018 Proposed Action, the Action Agencies will continue to support fish status and trend monitoring for one population per MPG for the following life stages: returning adult fish (e.g., PIT arrays in fish ladders, tributary PIT arrays and weirs, redd surveys for Chinook), smolt outmigration abundance and condition (e.g., screw traps), and smolt movement and survival (PIT tagging and associated arrays).

Additional monitoring for habitat or fish status and trends will be evaluated through the development of the forthcoming Columbia River Basin habitat RM&E strategy. The Action Agencies will leverage existing efforts capturing habitat or fish status and trends information funded by regional partners and entities wherever possible to address additional or unmet needs.

D.10.2 Implementation and compliance monitoring

To ensure habitat improvement actions are implemented as planned (e.g., meeting construction design and environmental compliance requirements), the Action Agencies fund ongoing implementation and compliance (I&C) monitoring for completed habitat actions. Generally, I&C monitoring data are used to inform Action Agency habitat program management and can also be used to support science-based analytical tools employed by NMFS such as life cycle modeling.

D.10.3 Effectiveness monitoring

The Action Agencies will support effectiveness monitoring related to their habitat mitigation efforts at a range of scales including the site and watershed scales. This monitoring serves multiple purposes, including determining if habitat actions are meeting their physical and/or biological objectives (limiting conditions and relative abundance in ESA-listed species), as well as revealing the benefit of actions on larger scales. To date, many key management questions have been addressed through a variety of Action Agency, NMFS, and regional effectiveness monitoring efforts including site-scale programmatic monitoring intensively monitored watersheds (IMWs).

D.10.3.1 Site-scale effectiveness monitoring

Bonneville will continue to fund site and project-scale action effectiveness monitoring (AEM) through completion of this programmatic project study design in 2023 to provide a comprehensive, consistent, efficient, and cost-effective approach to monitor and evaluate the Action Agencies' salmon and steelhead tributary habitat improvement actions (e.g., fish passage, instream wood structures, floodplain enhancement, and riparian improvement). The majority of Bonneville's implementation partners conduct site-scale effectiveness monitoring through the AEM Programmatic, including multiple habitat actions distributed across the Snake River, upper Columbia River, and middle Columbia River ESUs/DPSs. Results from this work are available on a rolling basis as action categories monitored in the AEM program are completed and evaluated.

D.10.3.2 Watershed-scale effectiveness monitoring

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 Bonneville. The Action Agencies will continue to support fish status and trend monitoring within the

Entiat, Lemhi, and John Day Basins, all of which were identified as pilot IMWs in the 2008 BiOp, as a subset of the fish status monitoring actions described in Section 2.5. These monitoring results will be made available to inform future effectiveness monitoring called for in the Columbia River Basin tributary habitat RM&E strategy.

The Action Agencies will continue to support ongoing habitat monitoring for a subset of readily available and high-value habitat variables, including stream temperature and flow. The results of this monitoring will be evaluated for integration into regional data display platforms through collaborative efforts with regional experts, including the U.S. Forest Service Rocky Mountain Research NorWeST team. Bonneville will continue to fund the development of stream habitat linear networks to display habitat attributes (e.g., stream temperature and flow) in GIS-based data displays and maps in select priority watersheds. Additionally, biologically based fish linear networks (e.g., salmon densities) are being explored for use in conjunction with stream habitat linear networks to help guide future habitat improvement efforts.

Results of site and watershed-scale effectiveness monitoring will continue to be used to guide future habitat action implementation to ensure the Action Agencies are investing in effective habitat improvement actions designed to help address uncertainty related to any residual adverse effects of CRS management. Additionally, results will be used to help evaluate improvements in habitat and fish status resulting from completed habitat actions in the Columbia River Basin through coordination with the THSC, the science committee, and evaluation in regional science-based processes such as life cycle modeling. The development of the regional habitat RM&E strategy will include considerations and recommendations for future effectiveness monitoring.

D.10.4 Research

The Action Agencies recognize the value of focused, cost-effective, time-bound research and validation monitoring that increases our understanding of the cause-and-effect relationships between habitat actions and biological fish responses. The forthcoming habitat RM&E strategy will include recommendations for future research priorities consistent with regional critical uncertainties (e.g., Independent Scientific Advisory Board [ISAB] Critical Uncertainties report and the Council's Fish and Wildlife Program Research Plan). In collaboration with NMFS and when necessary to inform management decisions, the Action Agencies will fund fish and habitat research projects with regional partners as priorities and Action Agency funding availability allows.

D.11 ADAPTIVE MANAGEMENT/DECISION SUPPORT

The Tributary Habitat Improvement Program adaptive management and decision support system identified in Figure D-7 will affect operational levels from policy to project-level. At the higher levels for changes in basin priorities, reporting metrics, level of effort between basins, and other regional efforts, the THSC will provide a key function in program adaptive management. The THSC, in coordination with the Science Committee, state and tribal salmon managers, local planning entities and efforts such as the IRA/MRA process and Atlas, habitat RM&E results and life cycle model (LCM) information, will evaluate current Tributary Habitat Improvement Program methods and adapt them as necessary to maximize the fish benefit. The THSC will act in a consensus manner to adapt the Tributary Habitat Improvement Program. The THSC will also help facilitate improved communication and information transfer between basins, from the RM&E program to the implementation program, and from executive decision-makers to the field and vice versa. The improved information transfer will help successes and lessons learned move between basins and help guide habitat actions.

High-quality planning and prioritization efforts in subbasins and MPGs such as the Upper Salmon IRA/MRA process and the Grande Ronde Atlas Process are also a part of the adaptive management process and they are updated routinely and incorporate the best available information. These planning efforts help direct the project effort to the highest priority projects and stream reaches.

Additionally, the THSC and Science Committee will be a direct path for new RM&E information to be tied directly to implementation planning and to direct implementation information to RM&E practitioners. Creating a better feedback loop between the two efforts will lead directly to faster and better adaptation to new information.

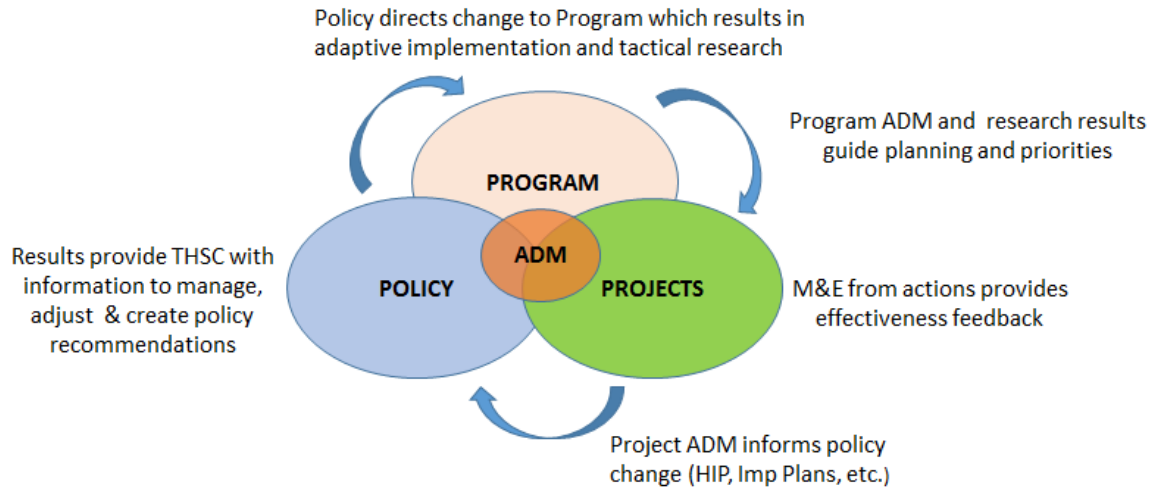


Figure D-7. Conceptual adaptive management model for ongoing Tributary Habitat Program improvement

D.11.1 Adaptive Management of Program Performance Metrics

The Action Agencies have identified metrics for the various habitat improvement action types at the MPG level for the time frame of this Proposed Action. These metrics become more uncertain farther into the future. For example, the Action Agencies can predict with relative certainty the actions to implement in the first 5 years of this Proposed Action. However, some planned actions may not come to fruition, some actions may change as they proceed through the design and permitting process, and some new opportunities for actions may arise. Forecasting farther into the future becomes uncertain. While the Action Agencies can assert that metrics identified at the MPG level (or their equivalent) can be implemented during the Proposed Action, they cannot identify which actions in which locations will occur.

Therefore, implementation action and metric forecasting and evaluation of program progress will occur across the time period of the Proposed Action through discreet reporting periods consistent with the 5-year evaluation cycles mentioned previously. The THSC will evaluate (1) year one through year four, (2) year five through year nine, and (3) year 10 through year 14, etc. As described above, accurate forecasting of implementation metrics will be difficult to determine beyond a 5-year time horizon. At 5-year intervals, the Action Agencies therefore will provide an estimate of specific actions and metrics with the understanding that NMFS species status reviews, new climate and fisheries science, and the

ongoing development and improvement of LCMs and other tools for identifying, prioritizing, and evaluating the projected benefits of suites of actions are all resources that can be applied in evaluating required changes or shifts in watershed priorities over time. LCMs are anticipated to provide a valued resource in evaluating potential suites of actions and scenarios to an “envelope” approach of possible combinations of conservation actions. This approach will provide valuable insight for the THSC in adjusting reporting and performance metrics in periods two and three. The THSC will use this analysis to adaptively manage the strategic approach and provide valuable information in determining program adjustments to optimize benefits.

D.12 POPULATION SPECIFIC ACCOMPLISHMENT METRICS 2007–2018

Table D.5, Table D.6, Table D.7, and Table D.8 summarize completed habitat metrics for the period 2007–2018 for Chinook salmon ESUs and Steelhead DPSs.

Table D.5. Completed Habitat Metrics 2007–2018 Chinook (Spring Summer) [Snake River ESU]

Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
Dry Clearwater										
Lapwai/Big Canyon	10	1	0	49	0	0	2,658	40	57	2
Potlatch River	4	1	43	102	0	0	590	20	43	0
Lawyer Creek	2	0	63	0	0	0	0	4	0	0
Upper South Fork Clearwater	5	0	19	339	0	0	486	54	73	10
Grande Ronde / Imnaha										
Catherine Creek	145	0	32	178	4,050	21	542	185	55	18
Big Sheep Creek	110	1	0	79	583	6	915	0	0	0
Grande Ronde River upper mainstem	79	0	9	0	0	0	0	1,061	107	53
Imnaha River mainstem	4	0	11	97	24,781	263	124	1	0	0
Lostine River	42	0	1	77	0	0	611	42	5	3

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Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
Lower Snake										
Asotin Creek	37	0	2	66	0	0	372	181	25	10
Tucannon River	35	0	1	5	0	0	0	1,027	15	41
Middle Fork Salmon River										
Big Creek	0	0	0	0	0	0	0	0	0	0
Camas Creek	0	5	1	0	0	0	0	0	0	0
Marsh Creek	0	78	21	3	0	0	0	0	0	0
Chamberlain Creek	0	0	6	59	0	0	122	0	0	0
South Fork Salmon River										
East Fork South Fork Salmon River	0	0	1	31	0	0	1	11	5	1
Little Salmon River	0	41	3	1	0	0	113	0	0	0
Secesh River	0	2	94	11	0	0	8	0	14	0
Upper Salmon River										
East Fork Salmon River	8	0	28	85	20,938	240	165	5	0	2
Lemhi River	8	9	0	63	5,273	42	47	274	8	13

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Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
East Fork Salmon River	8	0	28	85	20,938	240	165	5	0	2
Lemhi River	8	9	0	63	5,273	42	47	274	8	13
Pahsimeroi River	2	0	7	0	0	0	0	86	14	11
Panther Creek	0	0	4	15	13,748	55	16	100	0	3
Salmon River lower mainstem below Redfish Lake	0	98	2	25	12,926	108	7	30	100	3
Salmon River upper mainstem above Redfish Lake	0	98	10	4	1,778	24	20	82	2	13
Valley Creek	16	3	35	2	0	0	62	0	0	0
Yankee Fork	22	9	17	96	0	0	286	0	2	0
Wet Clearwater										
Lochsa River	5	2	14	16	0	0	0	0	92	0
Meadow Creek	1	0	47	38	0	0	73	0	0	0
Lolo Creek	30	524	47	117	23,709	141	435	19	9	0

Table D.6. Completed Habitat Metrics 2007–2018 Chinook (Spring Summer) [Upper Columbia River ESU]

Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
Upper Columbia / East Slope Cascades										
Entiat River	28	0	23	107	15,439	100	246	1	5	1
Methow River	22	0	283	8	7,944	39	170	314	16	9
Wenatchee River	225	0	38	1,985	123,896	638	8,857	0	2	0

Table D.7. Completed Habitat Metrics 2007–2018 Steelhead (Summer Winter) [Middle Columbia River DPS]

Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
Cascades Eastern Slope Tributaries										
Deschutes River - eastside	9	0	3	5	5,238	17	92	1,931	115	113
Deschutes River - westside	7	0	11	0	11,321	112	126	1,716	6	51
Fifteenmile Creek (winter run)	7	0	0	126	0	0		2,441	38	160
Klickitat River	7	0	0	0	0	0	41	22	26	1
Rock Creek	0	0	3	0	468	2	0	31	9	5
White Salmon River	0	0	149	7	12,608	30	0	0	0	0
Crooked River	104	0	61	633	21,898	155	2,876	0	0	0
John Day River										
John Day River lower mainstem tributaries	78	0	20	132	14,541	125	632	7,402	144	524

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Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
John Day River upper mainstem	27	0	22	84	1,163	4	1,069	1,343	51	105
Middle Fork John Day River	25	0	4	213	1,740	10	940	1,684	61	86
North Fork John Day River	6	0	48	9	0	0	49	2,350	34	93
South Fork John Day River	61	0	3	568	34,299	192	2,346	657	22	55
Umatilla and Walla Walla River										
Touchet River	55	0	23	166	5,712	56	1,783	896	24	21
Umatilla River	56	0	0	301	25,861	107	166	2,370	121	29
Walla Walla River	5	0	48	0	189	1	0	0	11	0
Willow Creek	44	0	7	532	32,977	116	2,653	252	0	24
Yakima River Group										
Naches River	15	0	6	94	8,062	0	1,790	793	6	5

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Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
Satus Creek	3	0	33	181	0	0	230	24,818	0	181
Toppenish	29	0	304	227	22,705	104	133	1,590	12	16
Yakima River upper mainstem	242	0	100	1,364	84,565	761	7,791	400	13	116

Table D.8. Completed Habitat Metrics 2007–2018 Steelhead (Summer Winter) [Snake River DPS]

Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
Clearwater River										
Clearwater River lower mainstem	9	0	14	42	0	0	213	64	100	2
Lochsa River	6	0	6	38	0	0	73	0	92	0
Lolo Creek	1	0	43	16	0	0	0	19	9	0
Selway River	5	0	73	339	0	0	486	0	0	0
South Fork Clearwater River	142	0	2	417	29,903	292	2,360	54	73	10
Grande Ronde River										
Grande Ronde River lower mainstem tributaries	125	0	4	277	4,925	28	2,118	5	0	1
Grande Ronde River upper mainstem	133	0	9	31	198	1	118	1,254	198	71
Joseph Creek	12	0	3	97	24,781	263	124	21	25	36

CRS Biological Assessment

Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
Wallowa River	5	0	3	25	0	0	0	42	5	3
Imnaha River										
Imnaha River	38	0	1	77	0	0	972	1	0	0
Lower Snake										
Asotin Creek	37	0	117	66	0	0	372	268	38	16
Tucannon River	62	0	1	259	54,662	469	439	1,027	15	41
Salmon River										
Big, Camas, and Loon Creek	2	0	1	14	6,962	38	16	0	0	0
East Fork Salmon River	2	0	42	3	0	0	0	28	100	4
Chamberlain Creek	6	0	0	85	20,938	240	165	0	0	0
Lemhi River	6	0	11	0	0	0	0	274	8	13
Middle Fork Salmon River upper mainstem	0	0	30	31	0	0	1	0	0	0

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Habitat Area	Instream Miles Improved	# of Screens Installed	# of Barriers Addressed	Stream Miles with Improved Access	Water Protected Acre - ft.	Water Protected in CFS	Riparian Acres Improved	Riparian Acres Protected	Stream Miles Improved in Riparian Areas	Stream Miles Protected in Riparian Areas
Little Salmon and Rapid River	2	0	0	65	12,059	60	47	0	0	0
Pahsimeroi River	2	0	16	0	0	0	0	93	14	12
Panther Creek	16	0	1	31	14,703	132	89	100	0	3
Salmon River upper mainstem	16	0	9	1	0	0	113	82	4	13
Secesh River	0	0	76	27	0	0	9	0	14	0
South Fork Salmon River	36	0	76	231	40,373	482	1,610	11	5	1
Upper Columbia / East Slope Cascades										
Entiat River	8	3	6	2	326	2	18	1	5	1
Methow River	20	9	18	107	15,439	100	246	314	16	9
Okanogan River	7	84	29	113	8,241	303	272	106	26	10
Wenatchee River	1	2	23	8	15,767	74	171	0	3	0
Crab Creek	0	0	0	0	600	3	903	0	0	0

D.13 REFERENCES

- Beechie T, E Beamer, and L Wasserman. 1994. Estimating Coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. *North American Journal of Fisheries Management* 14(4):797-811.
- Beechie T J, GR Pess, and H Imaki. 2012. Estimated changes to Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) habitat carrying capacity from rehabilitation actions for the Trinity River, North Fork Trinity to Lewiston Dam. Contract Rep. to the U.S Fish and Wildlife Service, Arcata, CA. NWFSC, Seattle, WA.
- Beechie T, H Imaki, J Greene, A Wade, H Wu, G Pess, P Roni, J Kimball, J Stanford, P Kiffney, and N Mantua. 2013b. Restoring salmon habitat for a changing climate. *River Research and Applications* 29(8):939–960. Online at <http://dx.doi.org> [DOI name 10.1002/rra.2590, accessed 3 December 2019].
- Bonneville. 2019. Missing reference in a Table: Tributary habitat improvement metrics taken from unknown Bonneville report.
- Cooney, T. D. In Press. Identifying Interior Columbia Basin ESU focal populations for near-term tributary habitat recovery efforts. In: R. Zabel, and C. Jordan (eds.), *Life cycle models of Interior Columbia River Basin spring and summer Chinook populations*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-xxx. <https://doi.org/xx.xxxx/xx/TM-NWFSC-xxx>, 500 pp.
- Copeland T, WC Schrader, B Barnett, MT Davison, KA Apperson, M Belnap, E Brown, and EA Felts. 2018. Idaho Chinook Salmon spawning ground surveys: protocol and historic trends. Idaho Department of Fish and Game, Annual Report 19-16, Boise, ID.
- Corps, Reclamation and Bonneville. 2017. Endangered Species Act Federal Columbia River Power System 2016 comprehensive evaluation: section 2. Detailed description of Reasonable and Prudent Alternative (RPA) action implementation. Portland, OR: U.S. Army Corps of Engineers (Corps), Northwestern Division; Bureau of Reclamation (Reclamation), Pacific Northwest Region; Bonneville Power Administration (Bonneville). Available at <https://www.salmonrecovery.gov/BiologicalOpinions/FCRPSBiOp/fcrps-2016-comprehensive-evaluation>.
- CTUIR (Confederated Tribes of the Umatilla Indian Reservation). 2017. Confederated Tribes of the Umatilla Indian Reservation CC44 Southern Cross Floodplain Habitat Improvement Project (2017).
- ESA (Endangered Species Act). 2013. Endangered Species Act Section 7 Formal Programmatic Biological Opinion, Letter of Concurrence, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Bonneville Power Administration’s Habitat Improvement Program III (HIP III) KEC-4 NMFS No: 2013/9724. Issued March 22nd, 2013.
- Henning, JA, RE Gresswell, and IA Fleming. 2006. Juvenile salmonid use of freshwater emergent wetlands in the floodplain and its implications for conservation management. *North American Journal of Fisheries Management* 26:367–376.

- Hillman, T, P Roni, and J O’Neal. 2016. Effectiveness of tributary habitat enhancement projects. Report to Bonneville Power Administration, Portland, OR.
- Idaho OSC Team (Idaho Governor’s Office of Species Conservation and partners). 2019. Upper Salmon Subbasin Habitat Integrated Rehabilitation Assessment. Assessment prepared for and with the U.S. Department of the Interior, Bureau of Reclamation. June 2019. 625 pp.
- Pollock MM, GR Pess, and TJ Beechie. 2004. The importance of beaver ponds to Coho salmon production in the Stillaguamish River basin, Washington, USA. *North American Journal of Fisheries Management* 24(3):749-760.
- Reeves GH, FH Everest, TE Nickelson and E Thomas. 1989. Identification of physical habitats limiting the production of Coho salmon in western Oregon and Washington. USDA Forest Service - Pacific Northwest Research Station Resource Monitoring & Assessment Program, PNW-GTR-245, Portland, Oregon.
- Roni P, GR Pess, TJ Beechie, and KM Hanson. 2014. Fish-habitat relationships and the effectiveness of habitat restoration. U.S. Dept. Commerce. NOAA Tech. Memo. NMFS-NWFSC-127.
- Roni P, R Timm. 2016. Lewis River Project – Limiting Factors and Identification of Restoration Alternatives to Fish Passage. Contract Rep. to Pacificcorps, Portland, OR. Cramer Fish Sciences, Gresham, OR.
- USFWS (U.S. Fish and Wildlife Service). 2008. Biological Opinion (BiOp) for the Continued Operation and Maintenance of the Bureau of Reclamation’s Umatilla/Umatilla Basin Projects and Bonneville Power Administrations-funded Fish Passage and Screening Structures, Umatilla County Oregon. U.S. Fish and Wildlife Service, July 2008.
- Zabel R, T Beechie, G Pess, C Jordan, M Bond, T Nodine, J Jorgensen, M Beakes. 2016. A Habitat Assessment Approach for Restoration Planning. Presentation delivered at the May 4, 2016 - Columbia Basin Partnership Workshop. Northwest Fisheries Science Center, Seattle, WA.

**Consultation Package for
Operations and Maintenance of the
Columbia River System**

**APPENDIX E – COLUMBIA RIVER SYSTEM OPERATIONAL AND STRUCTURAL
IMPROVEMENTS UNDER THE ENDANGERED SPECIES ACT – 2020 PROGRESS
UPDATE**

Bonneville Power Administration,
Bureau of Reclamation,
U.S. Army Corps of Engineers

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E.1 PURPOSE AND SCOPE

When developing the action detailed in Chapter 2, the Action Agencies reviewed relevant data collected primarily since the 2008 biological opinion (BiOp) was completed; however, a broader understanding of long-term achievements and a retrospective glance of the region's progress over nearly 4 decades of operational and structural improvements to improve juvenile and adult Pacific salmon and steelhead passage and survival. The management actions and evaluations associated with these improvements are the responsibility of the U.S. Army Corps of Engineers (Corps), Bureau of Reclamation (Reclamation) and the Bonneville Power Administration (Bonneville). This appendix primarily focuses on how the eight federal, multi-purpose dams with fish passage in the lower Snake and lower Columbia Rivers (fish passage dams) have been updated with structural modifications to current configurations and operations. It also examines the associated effects on juvenile and adult salmon and steelhead life stages, including the effects of smolt transportation (Figure E-1).

The purpose of this appendix is to provide updates to many of the analyses and datasets discussed in their 2013 summary of hydro configuration and operations modifications (Bonneville et al. 2013) and to provide additional context and background to the actions previously taken and currently proposed in Chapter 2 of this Proposed Action. This appendix provides some additional results of biological studies conducted by the Action Agencies under the 2019 National Marine Fisheries Service (NMFS) Columbia River System (CRS) 2019 BiOp and 2008 NMFS Fisheries Federal Columbia River Power System BiOp, as supplemented in 2010 and 2014 (collectively referred to herein as the 2008 BiOp) that were not available during the previous consultation with NMFS, initiated in 2018. More specifically, additional results from juvenile salmon downstream passage studies conducted in 2018 during the injunction spill and 2019 flexible spill have also been included in this updated document.

Achievements in fish passage throughout the CRS have been made for multiple species, including resident fish (e.g., lamprey and bull trout); however, this appendix focuses on ESA-listed species in consultation with the Services. A summary of some of these accomplishments includes:

- Juvenile fish passage survival at the CRS dams for spring and summer migrants were 96 percent and 93 percent, respectively, as compared to when the Northwest Power Act was passed and the estimated average juvenile mortality at each mainstem dam and reservoir complex was 15–20 percent with losses recorded as high as 30 percent (*Appendix E of NPPC 1987*; Corps et al. 2017).
- Travel time has improved for yearling Chinook and juvenile steelhead through the system thanks to the combination of spill and spillway weirs and other surface passage routes, even in low flow years such as 2015 (Corps et al. 2017).
- Total in-river survival has improved for migrating juvenile salmon and steelhead. Comparing two time periods reported in NMFS reach studies (1997–2007 and 2008–2017), there has been a nearly 10 percent survival increase for hatchery and wild sockeye salmon, a 2 percent increase in hatchery and wild Chinook (3 percent for wild), and a 20 percent survival increase for hatchery and wild steelhead (13 percent for wild) (Widener et al. 2018).
- Significant federal investment in structural improvements and operational changes in the system are helping to achieve the results listed above (Bonneville et al. 2013).

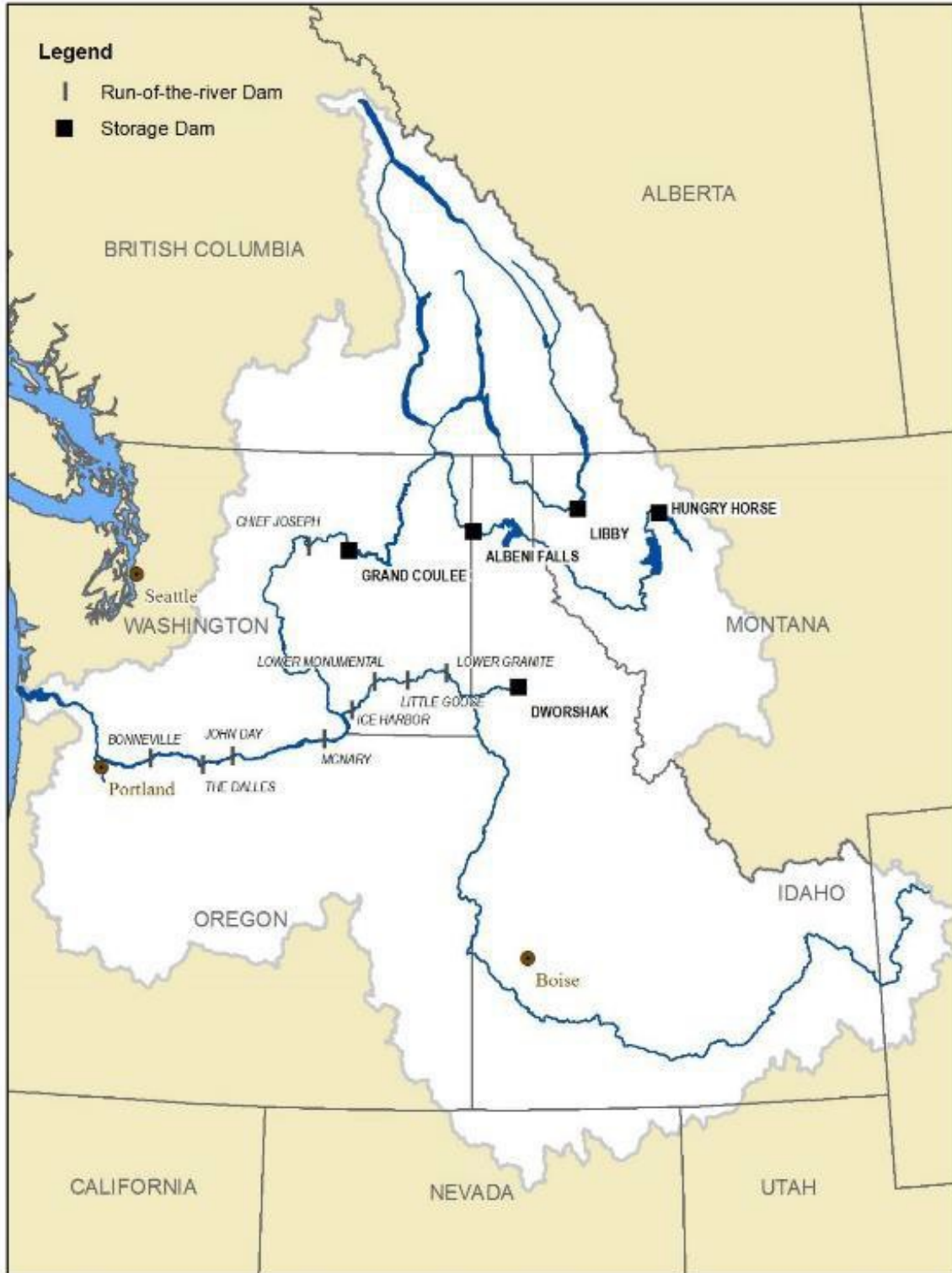


Figure E-1. The 14 federal CRS multiple-use projects, including four on the lower Columbia River (Bonneville Dam, John Day Dam, The Dalles Dam, McNary Dam) and four on the lower Snake River (Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, Lower Granite Dam)

E.2 CONFIGURATION AND OPERATIONAL IMPROVEMENTS UNDER THE 2008 BIOP

The 2008 BiOp was broad in scope, and its Reasonable and Prudent Alternatives (RPA) called for a variety of actions affecting salmon and steelhead throughout their life cycle, with the goal of improving the survival and productivity of each listed species (evolutionary significant unit [ESU] or distinct population segment). Actions included improving passage conditions through the CRS, as well as additional conservation actions, such as improving habitat conditions in spawning tributaries and the Columbia River estuary, reducing predation in the migratory corridor, and completing updates to hatchery genetic management plans.

Survival standards in the 2008 BiOp called for 96 percent and 93 percent dam passage survival of spring- and summer-migrating juveniles, respectively, at each of the eight CRS dams on the lower Columbia and Snake Rivers. Actions to accomplish this have included installation of surface passage systems, improved turbine designs and upgrades of screened bypass systems to improve how and where fish are returned to the river below dams, as well as spill operations tailored to the unique structural configuration of each dam. Most of these modifications have now been designed, installed or implemented, and tested through a rigorous performance standard testing methodology. In their 2017 supplemental hydrosystem module for recovery planning NMFS found that survival studies show that with few exceptions, these measures are performing as expected and are very close to achieving, or are already achieving, the juvenile dam passage survival objectives of 96 percent for yearling Chinook salmon and steelhead and 93 percent for subyearling Chinook salmon in the supplemental 2014 BiOp (NMFS 2017).

E.2.1 Dam-specific spill operations

Spill has long been an important tool employed by the Action Agencies to reduce the proportion of fish passing through turbines and increase overall dam passage survival. Spill was first used to pass juvenile fish at Bonneville, The Dalles Dam, John Day Dam, Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam in 1983. Since 1983, Action Agency and regional scientists and engineers have conducted many years of extensive engineering and biological studies to understand how to best operate spillways to accommodate downstream juvenile fish passage without excessive total dissolved gas (TDG) generation or impeding upstream adult passage. In recent years, spill has become increasingly important with the installation of spillway weirs, which pass surface volumes of water. Because of their high fish passage effectiveness, surface passage structures such as spillway weirs pass large numbers of fish with less flow than conventional spill bays.¹ Since the early 2000s, much of the Action Agencies' focus has been on using spill in conjunction with surface passage structures to facilitate safer juvenile fish passage at dams and reduce power house encounters. In general, the addition of surface

¹ At some projects, increased spill also may increase the proportion of river flow going through conventional spill bays, drawing fish away from the spillway weir, which testing at the dams has demonstrated is typically the safest passage route. For example, NMFS noted in an assessment of passage in 2008 at Ice Harbor Dam, there exists a point of diminishing returns, where additional spill reduces the overall effectiveness of the spillway weir, as well as the spillway as a whole (Axel et al. 2010).

passage structures at all eight dams², combined with refined spill operations, has resulted in decreased proportions of juveniles that pass through powerhouses and turbines, decreased forebay residence times, reduced the number of juvenile fish diverted through the fish bypass facilities at some dams, and increased overall dam survival. Additional traditional (bottom) spill was applied to spring spill operations in 2018 and 2019 to further decrease the likelihood of juvenile salmonids passing through the turbines or bypass systems with a goal of increasing overall hydro system survival.

Determining the appropriate spill level and pattern can involve balancing competing objectives. It is important to understand that more spill is not necessarily better for fish. For example, high spill volumes can delay the migration of adult fish moving upstream and generate increased dissolved gas levels in the river, which can be harmful to fish and other aquatic species in the water column. Spilling high volumes can increase the number of adults that fall back over the spillway (Reischel and Bjornn 2003; Harnish et al. 2019). This forces fish to locate fish ladders again, increasing both dam passage times and the total amount of energy expended by the fish as they migrate through the fish passage projects. Fish that take longer to pass dams are less likely to complete the migration to their final spawning locations (Caudillet et al. 2007).

The effects of gas supersaturation on juvenile and adult salmon caused by spill at levels that result in higher TDG levels has been a concern since the mid-1960s (Ebel and Raymond 1976). The U.S. Environmental Protection Agency water quality standards limit TDG to 110 percent saturation. However, the Oregon and Washington state regulatory agencies issued a standards modification (Oregon) or criteria adjustments (Washington) to allow higher TDG levels to facilitate higher levels of spill to aid passage of juvenile salmon. Spill levels are managed consistent with these applicable state water quality standards.³ Current TDG level limitations during fish spill operations are 120 percent in the tailrace of each dam; however, both states are currently revising their TDG standards and proposing levels up to 125 percent TDG. High TDG levels can be harmful to fish, salmonids and resident species, (e.g., monitoring of juvenile salmonids during conditions above 125 percent TDG result in gas bubble trauma), future uncertainties exist among adults, juveniles, embryos and larvae, and other aquatic species depending on water depth, temperature, and the physiological health of the organism (McGrath et al. 2006).

² The Dalles Dam does not have a surface weir installed at the spillway; however, the ice trash sluiceway has been modified and is an effective surface passage route for downstream migrants.

³ Prior to 2019 spring spill operations, Oregon TDG standard modification specifies that from April 1 through August 31 TDG levels are not to exceed 120 percent in the tailwater, measured as the average of the twelve highest hourly readings in any one day. The Washington criteria adjustment specifies that TDG levels are not to exceed either 120 percent in the project tailwater or 115 percent in the forebay of the next downstream dam. This is measured as the average of the twelve highest consecutive hourly readings in any one day. The criteria also specify that TDG levels are not to exceed 125 percent for more than 1 hour (State of Washington) or more than 2 hours (State of Oregon). In 2019, both states altered TDG standards to specify that during the same time period (April 1 – August 31) TDG levels were not to exceed 120 percent in the tailwater (removing the forebay criteria).

E.2.2 Benefits of surface passage

The 2008 BiOp recommended project-specific spill operations to facilitate safe fish passage at each of the lower Snake and lower Columbia Dams during the juvenile salmon migration. Along with these spill operations, spillway weirs and other surface passage routes were incorporated at all eight fish passage dams by 2010. Surface passage structures provide more natural passage conditions for juvenile salmon and steelhead and are designed to improve survival, reduce forebay residence time, and use water more efficiently by passing more fish through a given unit of water. Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, Ice Harbor Dam, McNary Dam, and John Day Dam have spillway weirs in one or more spill bays (Figure E-2 and Figure E-3). The Dalles Dam⁴ and Bonneville Dam have surface passage systems at the powerhouses.

These spill operations, along with spillway weirs and other surface passage routes, have reduced the percentage of fish that pass through power house turbines, decreased fish travel time, and increased the overall survival of juveniles through the system. Importantly, effective locations for surface passage at each dam were selected based on detailed analysis involving hydraulic modeling and site-specific fish monitoring studies. With the addition of spillway weirs and other improvements, new spill patterns were developed using the expertise of regional scientists and engineers. These spill patterns are designed to improve conditions leading to and exiting the spillways under the spill levels called for in the 2008 BiOp.

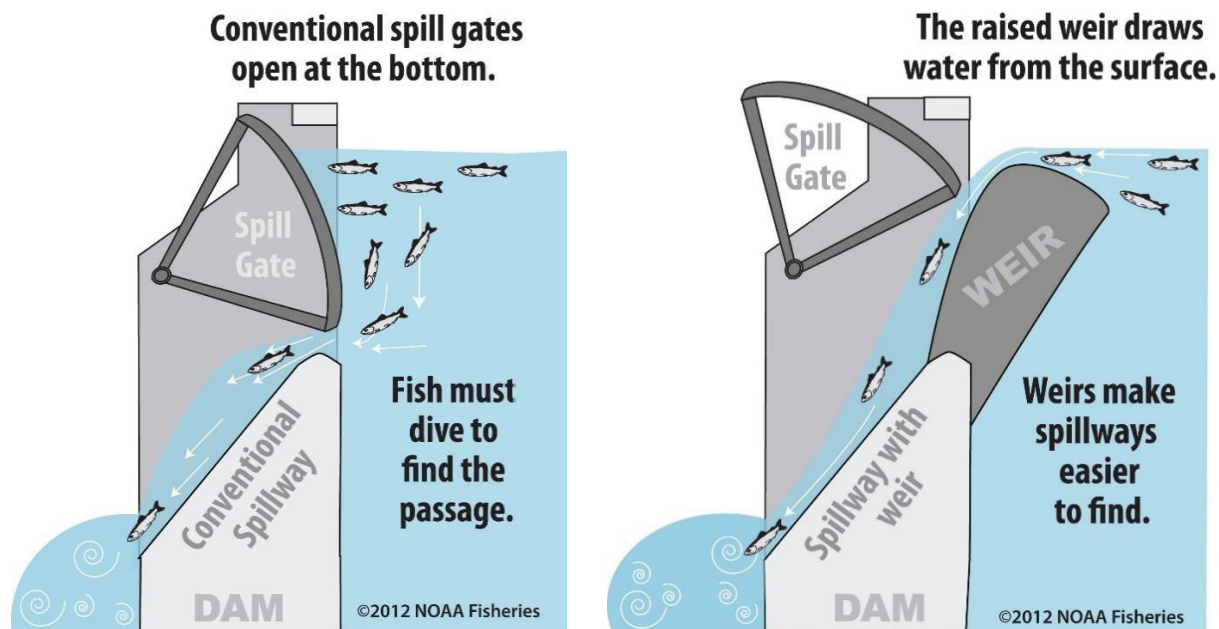


Figure E-2. Spillway weirs allow fish to pass dams at the surface, where they naturally travel

⁴ The Dalles Dam does not have a screened bypass system, and has a unique configuration where a surface spillway weir would not provide the same benefit as at other projects. Surface passage is provided by a sluiceway, similar to Bonneville Dam's first powerhouse.



Figure E-3. A spillway weir in operation at McNary Dam (surface spill shown in middle, bottom spill to left and right)

E.2.3 Improvements to powerhouse routes of passage

Fish can pass through the powerhouse at each dam through power-generating turbines or screened fish bypass systems. Although these two routes of passage are very different, some regional fish managers group them together to refer collectively as “powerhouse passage.”

Screened juvenile bypass systems are incorporated into powerhouses at seven CRS fish-passage dams to guide fish away from turbine intakes and into bypass channels.⁵ Several of the systems can be operated in either bypass mode, routing fish directly to the downstream tailrace to return them to the river, or collection mode, so that fish can be collected, counted and evaluated, and released downstream or, in some cases, transported. Since 2008, the screened bypass/collection systems have undergone substantial modifications, including a complete overhaul of the juvenile bypass system at Lower Granite Dam and relocating the bypass exits at McNary Dam, Lower Monumental Dam, and Little Goose Dam to reduce predation.

⁵ The exception is The Dalles Dam where, because of its unique right-angle configuration, a very small proportion of juveniles pass through the turbines.

Additional juvenile bypass modifications have been made at Bonneville Dam. The Corps continued field investigations and design of fish survival upgrades to the Bonneville Dam second powerhouse (PH2) juvenile bypass system. Previous modifications to that system resulted in an increase in the percentage of juvenile fish going through the bypass system rather than the turbines, but also increased the incidence of injury to juvenile fish, particularly to smaller juveniles when the turbines were operated at the upper end of the one percent peak efficiency range. In 2014, the Corps completed the installation of a recommended gatewell flow reduction device mounted in a single PH2 gatewell behind the barrier screen. Hydraulic and biological evaluations in 2015 indicated that the device performed as expected and reduced turbulence in the gatewell, improving hydraulic conditions and juvenile fish survival when operating the turbine unit. That modification has now been made to all PH2 units.

In early 2018, the Corps completed a major overhaul of the juvenile bypass system at Lower Granite Dam. The upgrades included replacing 10-inch gatewell orifices with larger 14-inch orifices, widening the collection channel, daylighting the transport channel, adding new primary dewatering structures, and constructing new primary and emergency bypass outfall structures. These upgrades are expected to increase juvenile fish survival by providing more efficient control of flow, improving the removal and passage of debris, increasing attraction flow for juvenile fish and reducing risk of predation at the outfall release point.

In addition to spill improvements and bypass system improvements, the Action Agencies have implemented turbine operations designed to increase juvenile fish survival. All powerhouse units are operated within a range that is intended to reduce injury and mortality. In addition, the turbine runners in all 10 units at Bonneville Dam Powerhouse 1 were replaced with a “minimum-gap” design which reduces both shear and impact injuries. At Ice Harbor Dam, the turbine runners are being replaced with new runners specifically designed to reduce injury and increase survival, and increase turbine efficiency. The runner in Unit 2 was replaced (2016–2019) and operational in the spring 2019. Unit 3 replacement is underway with a scheduled completion in 2021 and Unit 1 replacement will follow (tentative completion in 2022). Preliminary biological studies of passage at the improved fish passage turbine Unit 1 have indicated high passage survival (>98 percent) and low injury rates with no passage injuries associated with changes in pressure (Deng et al. 2019; Normandeau Associates 2019).

Although the proportion of juveniles passing via turbines has decreased throughout the system with the installation of surface passage routes at all eight dams, these upgrades at Bonneville Dam and Ice Harbor Dam reduce the risk of injury or mortality for those remaining fish that pass the dam through the turbines.

E.2.4 Other actions to improve fish passage

Structural modifications have also been completed in many dam tailraces to reduce TDG generation, improve juvenile egress away from the dam, and reduce losses from predation. Flow deflectors were installed in most spill bays at the lower Snake and lower Columbia River Dams to reduce TDG generation. A concrete wall was installed below The Dalles Dam to keep smolts in the main river channel and away from shallow areas where predation was a concern. Below The Dalles Dam and John Day Dam, improved aerial wire arrays were installed to reduce losses to avian predators.

The Action Agencies have also employed additional actions to improve survival of salmon and steelhead by deterring or managing the number of piscivorous fish, marine mammals, and bird predators to reduce the impacts from predation on juvenile and adult salmon.

E.3 JUVENILE FISH RESPONSE – SPRING MIGRANTS

Annual survival estimates indicate an upward trend in survival of juvenile steelhead and Chinook salmon migrating through the Snake and Columbia Rivers over the last two decades. In general, more adult fish—and more wild adult fish—are returning to the river; however, there has been a downward trend in the last 5 years of returning adult salmon and steelhead. The current trend of the combined number of natural-origin and hatchery-origin adult fish returning from the ocean is higher than in the 1990s in nearly all years, and in several cases the highest since dam counts first began at Bonneville Dam in 1938. Ocean conditions and other factors have a significant impact on salmon returns, but analyses indicate that these upward trends in the survival of juvenile fish passing through the system and subsequent adult returns are at least partially attributable to the collective management actions implemented at individual dams and across the hydro system.

E.3.1 Juvenile dam survival

Dam passage survival is defined as, “survival from the upstream face of a dam to a standardized reference point in the tailrace immediately below the dam.” Successful performance tests for 2 years were required to meet the 2008 BiOp performance standards. Extensive testing has demonstrated that yearling Chinook salmon and steelhead survival rates past dams are at or near the 2008 BiOp performance standard of 96 percent survival through the dams tested to date.

A summary of dam survival test results conducted under the 2008 BiOp indicate the estimated survival of yearling Chinook ranged from 95.20 percent to 99.21 percent and estimates of steelhead survival ranged from 94.50 percent to 99.59 percent (ETable E-1). NMFS used information contained in Table E-1, to confirm that, with few exceptions, the measures the Action Agencies implemented under the 2008 BiOp are performing as expected and are achieving, or are very close to achieving, the juvenile dam passage survival objectives (NMFS 2017).

ETable E-1. Juvenile dam passage survival estimates, passage times, and spill passage efficiency for yearling Chinook salmon and juvenile steelhead derived from performance standard tests from 2010–2018

Dam	Year ^a	Species	Dam Passage Survival (% with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (%)	Spill Operation (Target / Actual)
Bonneville ^{b,c}	2010	Yearling Chinook Salmon	95.20 (0.40)	0.74	52.8	100 kcfs / 100 kcfs (30 Apr – 13 May)

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Dam	Year ^a	Species	Dam Passage Survival (% with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (%)	Spill Operation (Target / Actual)
Bonneville ^d	2011	Yearling Chinook Salmon	95.97 (1.76)	0.55	56.6	100 kcfs / 181 kcfs (season-wide)
Bonneville ^{b,c}	2010	Steelhead	94.50 (0.43)	1.69	40.6	100 kcfs / 100 kcfs (30 Apr – 13 May)
Bonneville ^d	2011	Steelhead	96.47 (2.12)	0.85	54.4	100 kcfs / 181 kcfs (season-wide)
Bonneville ^e	2018	Yearling Chinook Salmon	98.66 (3.03)*	n/a	n/a	Gas Cap / Forced spill May-early June
Bonneville ^e	2018	Steelhead	96.37 (2.65)*	n/a	n/a	Gas Cap / Forced spill May-early June
The Dalles ^{f,g}	2010	Yearling Chinook Salmon	96.41 (0.96)	1.28	84.07	40% / 39.9%
The Dalles ^{f,g}	2010	Steelhead	95.34 (0.97)	1.28	87.70	40% / 39.9%
The Dalles ^h	2011	Yearling Chinook Salmon	96.00 (0.72)	0.97	65.8	40% / 43.1%
The Dalles ^h	2011	Steelhead	99.52 (0.83)	0.81	75.4	40% / 43.1%
John Day ⁱ	2011	Yearling Chinook Salmon	96.66 (1.03) 97.84 (1.07) 96.76 (0.71)	2.0 1.5 1.42	61.2 66.4 63.68	30% / 30% 40% / 40% Season-wide
John Day ⁱ	2011	Steelhead	98.36 (0.90) 98.97 (0.96) 98.67 (0.61)	4.3 3.2 2.91	61.2 66.4 62.78	30% / 30% 40% / 40% Season-wide
John Day ^j	2012	Yearling Chinook Salmon	96.73 (0.65)	1.15	74.56	30% / 37.1% 40% / 37.1%
John Day ^j	2012	Steelhead	97.44 (0.28)	2.39	74.52	30% / 37.1% 40% / 37.1%
McNary ^k	2012	Yearling Chinook Salmon	96.16 (1.40)	1.76	72.46	40% / 50.9%
McNary ^k	2012	Steelhead	99.08 (1.83)	1.78	83.15	40% / 50.9%

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Dam	Year ^a	Species	Dam Passage Survival (% with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (%)	Spill Operation (Target / Actual)
McNary ^l	2014	Yearling Chinook Salmon	96.10 (1.27)	1.73	71.40	40% / 52.6%
McNary ^l	2014	Steelhead	96.98 (1.36)	2.57	84.33	40% / 52.6%
McNary ^e	2018	Yearling Chinook Salmon	99.21 (1.54) [*]	n/a	n/a	Gas Cap / Forced spill May–early June
McNary ^e	2018	Steelhead	98.03 (1.00) [*]	n/a	n/a	Gas Cap / Forced spill May–early June
Lower Monumental ^m	2012	Yearling Chinook Salmon	98.68 (0.90)	2.35	78.89	Gas Cap (26 kcfs) / 29.7 kcfs
Lower Monumental ^m	2012	Steelhead	98.26 (0.21)	2.17	65.85	Gas Cap (26 kcfs) / 29.7 kcfs
Little Goose ⁿ	2012	Yearling Chinook Salmon	98.22 (0.76)	2.58	65.28	30% / 31.8%
Little Goose ⁿ	2012	Steelhead	99.48 (0.81)	2.67	56.09	30% / 31.8%
Little Goose ^e	2018	Yearling Chinook Salmon	98.21 (0.55) [*]	n/a	n/a	Gas Cap / Forced spill May
Little Goose ^e	2018	Steelhead	99.01 (0.57) [*]	n/a	n/a	Gas Cap / Forced spill May
Lower Granite ^e	2018	Yearling Chinook Salmon	98.77 (0.63) [*]	n/a	n/a	Gas Cap / Forced spill May
Lower Granite ^e	2018	Steelhead	99.36 (0.37) [*]	n/a	n/a	Gas Cap / Forced spill May
Lower Granite ^o	2018	Yearling Chinook Salmon	97.26 (1.59) [*]	2.00	62.1	Gas Cap / Forced spill May
Lower Granite ^o	2018	Steelhead	99.59 (0.99) [*]	2.93	57.4	Gas Cap / Forced spill May

^{*}Survival was calculated using the Virtual/paired-release Model (VIPRE)

^a There were no tests conducted in 2015, 2016, or 2017. Spill passage efficiency is the percent of all downstream migrating juvenile salmon and steelhead that pass a dam through the spillway and other surface passage routes. Sources: ^b Ploskey et al. 2012, ^c Ploskey et al. 2011, ^d Skalski et al. 2012b, ^e Harnish et al 2019, ^f Skalski et al. 2010, ^g Johnson et al. 2011, ^h Skalski et al. 2012a, ⁱ Skalski et al. 2012e, ^j Skalski et al. 2013d, ^k Skalski et al. 2012d, ^l Skalski et al. 2014, ^m Skalski et al. 2013a, ⁿ Skalski et al. 2013b, ^o Skalski et al. 2019

E.3.1.1 Relationship between juvenile dam survival and SAR

Salmon survival can be measured over different distances and periods. Survival from the smolt life stage to maturity encompasses most of the salmon life cycle over a period of years and is often referred to as smolt-to-adult returns (SARs). This metric reflects the influence of many factors, most notably ocean conditions that may substantially increase or decrease salmon returns (Ryding and Skalski 1999). To provide a clear measure of improvements in dam passage survival at a single dam once a configuration or operational improvement has been completed, juvenile dam passage survival performance standard tests are conducted for two consecutive years to estimate juvenile dam passage survival. These estimates of survival differ from SARs in that the estimates are a snapshot of survival for juveniles passing a single dam whereas SARs span a greater portion of the fish's entire life cycle.

Monitoring protocols to estimate juvenile survival past each dam were developed by the Action Agencies in consultation with NMFS. These protocols have been peer reviewed and are standardized and systematic (Skalski et al. 2016). The performance standard tests are based on state-of-the-art experimental designs, fish tag technologies, and analytical frameworks. The tests also employ standardized fish handling and marking procedures across test sites. The protocols are used to develop annual estimates of survival, which are compared against the 96 percent performance standard specified in the 2008 BiOp. The Northwest Power and Conservation Council's Independent Scientific Review Panel called the testing design "well-reasoned, justified and described" and said the testing would provide important information on how fish pass dams and help assess the benefits of structural changes made at dams (ISRP 2009). Prior to the 2008 BiOp, testing focused on evaluating specific configurations and operations. The tests conducted were statistically rigorous and provided valuable information. Although dam passage survival research was conducted at a majority of dams in the CRS, researchers used a variety of tagging and mark-recapture experimental designs that varied across years and among dams. Early evaluations focused on testing specific configurations and operations. However, once the structural and operational improvements identified in the 2008 BiOp were in place, performance tests using standardized methods and techniques were recommended to estimate survival in a consistent manner across years and sites. Additionally, to ensure consistency, a single research team has monitored survival at CRS dams. Performance testing using the new methods began in 2010. (Figure E-4 and Figure E-5).

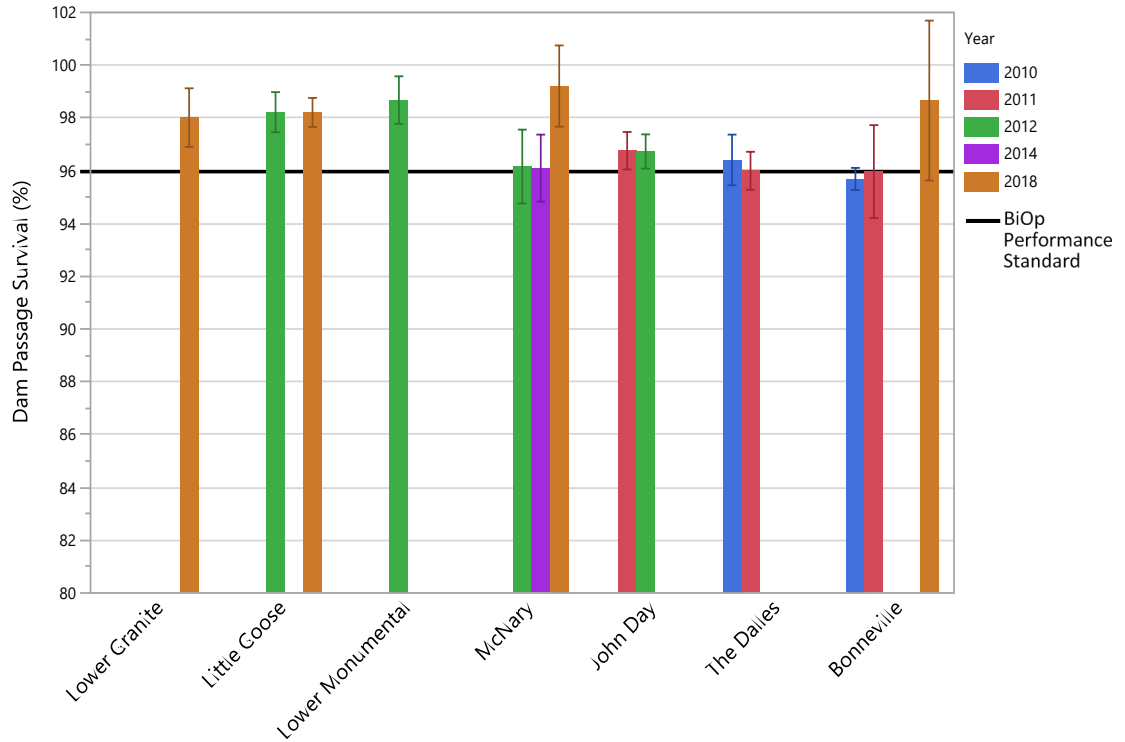


Figure E-4. Estimated dam passage survival for yearling Chinook salmon. The 2008 BiOp performance standard for yearling Chinook salmon was 96 percent. Bars represent annual mean survival estimates and standard error. Sources: Ploskey et al. 2012, Skalski et al. 2012b, Skalski et al. 2010, Skalski et al. 2012a, Skalski et al. 2012e, Skalski et al. 2013d, Skalski et al. 2012d, Skalski et al. 2014, Skalski et al. 2013a, Skalski et al. 2013b, Harnish et al. 2019, Skalski et al. 2019.

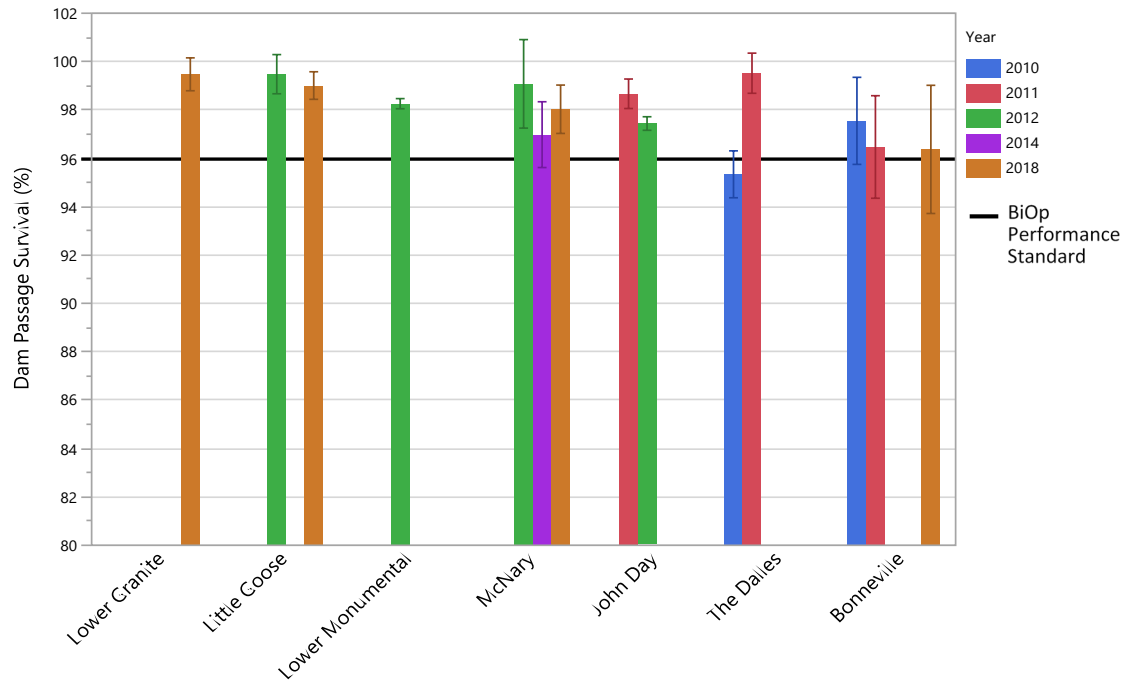


Figure E-5. Estimated dam passage survival for steelhead. The BiOp performance standard for steelhead is 96 percent. Bars represent annual mean survival estimates and standard error. Sources: Ploskey et al. 2012, Skalski et al. 2012b, Skalski et al. 2010, Skalski et al. 2012a, Weiland et al. 2013a, Weiland et al. 2013b, Skalski et al. 2012d, Skalski et al. 2014, Skalski et al. 2013a, Skalski et al. 2013b, Harnish et al. 2019, Skalski et al. 2019.

E.3.2 Reductions in dam passage time

The installation and operation of surface passage structures, combined with spill operation modifications, have resulted in faster passage of juvenile fish past dams. Travel time through the CRS (e.g., Lower Granite Dam to Bonneville Dam) is monitored using passive integrated transponder (PIT) tags. Acoustic-tagged fish released during performance standard tests were also used to monitor the transit time of juvenile salmon through the dam forebays. Forebays are the portion of reservoirs located immediately upstream from dams. Prior to the installation of surface passage structures, fish might spend several hours in a dam forebay before finding their way through standard spillway outlets, turbines, or screened bypass systems, all of which are 40 feet or more below the surface of the water. Prior to the 2008 BiOp, forebay delays were especially prevalent under conditions of no spill and low river flows. Reducing passage timing delay in the forebay has been demonstrated to reduce fish exposure to predators (Ferguson et al. 2005). Results of the most recent testing indicate that median forebay passage times for yearling Chinook salmon were relatively short and ranged from 0.6 hour at Bonneville Dam (Skalski et al. 2012b) to 2.6 hours at Little Goose Dam (Skalski et al. 2013b) and were typically less than 2 hours.

The 2.6-hour passage time at Little Goose was almost 30 percent less than the 3.6-hour passage time measured in the year prior to the installation of surface passage (Absolon et al. 2008). Median forebay

passage times for steelhead were also relatively short and ranged from 0.8 hour at The Dalles Dam (Skalski et al. 2012a) to 2.7 hours at Little Goose Dam (Skalski et al. 2013b).

E.3.3 Turbine and bypass passage

The suite of 2008 BiOp actions implemented to date has reduced the proportion of fish passing through the powerhouse (i.e., turbines and bypass systems), and increased the proportion going through routes such as spillways and surface passage. The combined proportion of juvenile fish passing through non-turbine routes is known as fish passage efficiency (FPE). FPE has increased significantly since the 2008 BiOp and is now on average above 90 percent for spring migrants and above 85 percent for summer migrants at all dams (Table E-2). FPE estimates are generally higher at lower Snake River dams than those in the Columbia River. With the installation of spillway weirs and other surface passage structures coupled with increased spill for juvenile fish passage, less juvenile fish are passing through powerhouses and as a result, juvenile fish are passing less frequently through screened juvenile bypass systems. While passage proportions vary by location, in general, passage at bypass systems at all locations has decreased from pre-BiOp levels of at or below 41 percent to typically less than 25 percent (Table E-3).

Table E-2. Estimated proportion (%) of juvenile fish migrating through non-turbine routes at mainstem Columbia and Snake River dams*

Location (Dam)	Year of Testing	Yearling Chinook Salmon FPE (%)	Steelhead FPE (%)	Subyearling Chinook Salmon FPE (%)
Bonneville ^a	2010	80.2	79.5	70.5
Bonneville ^b	2011	70.7	74.0	-
Bonneville ^c	2012	-	-	69.9
The Dalles ^{d,e}	2010	94.7	95.4	83.0
The Dalles ^f	2011	83.1	89.1	-
The Dalles ^g	2012	-	-	78.4
John Day ^{h,i}	2010	96.3	98.2	88.3
John Day ^j	2011	88.5	96.0	-
John Day ^k	2012	92.7	97.0	85.9
John Day ^l	2014	-	-	79.2
McNary ^m	2012	96.8	97.7	90.9
McNary ⁿ	2014	91.2	97.3	80.9
Lower Monumental ^o	2012	94.8	96.5	92.4
Little Goose ^p	2012	96.3	98.0	95.1
Lower Monumental ^q	2013	-	-	95.1
Little Goose ^r	2013	-	-	95.0

Location (Dam)	Year of Testing	Yearling Chinook Salmon FPE (%)	Steelhead FPE (%)	Subyearling Chinook Salmon FPE (%)
Little Goose ^f	2018	96.6	98.4	-
Lower Granite ^s	2018	92.9	96.6	91.3

*(Note: Commonly defined as Fish Passage Efficiency [FPE]).

Sources: ^a Ploskey et al. 2011, ^b Skalski et al. 2012b, ^c Skalski et al. 2013e, ^d Skalski et al. 2010, ^e Skalski et al. 2010a, ^f Skalski et al. 2012a, ^g Skalski et al. 2012c, ^h Weiland et al. 2012a, ⁱ Weiland et al. 2012b, ^j Skalski et al. 2012e, ^k Skalski et al. 2013d, ^l Skalski et al. 2014, ^m Skalski et al. 2012d, ⁿ Skalski et al. 2015, ^o Skalski et al. 2013a, ^p Skalski et al. 2013b, ^q Skalski et al. 2013c, ^r Harnish et al. 2019, ^s Skalski et al. 2019.

Table E-3. Estimated proportion (%) of juvenile fish migrating through screened bypass systems at mainstem Columbia and Snake River dams

Location ¹	Year of Testing	Yearling Chinook Salmon (%)	Steelhead (%)	Subyearling Chinook Salmon (%)
Bonneville Dam ^{a,b}	2010	6.5	5.9	3.3
	2011	4.3	1.7	-
John Day ^{c,d}	2010	6.3	9.4	10.7
	2011	24.8	33.2	-
McNary ^{e,f}	2012	24.2	14.5	12.5
	2014	20.0	12.9	27.0
Ice Harbor ^g	2008	14	22	21
Lower Monumental ^h	2009	20	29	30
Little Goose ⁱ	2009	24	41	24
Little Goose ^{j,k}	2012	30.97	41.91	-
	2018	26.6	39.8	-
Lower Granite ^l	2018	30.7	39.3	11.6

Sources: ^a Ploskey et al. 2011, ^b Ploskey et al. 2013, ^c Weiland et al. 2013a, ^d Weiland et al. 2013b, ^e Hughes et al. 2013, ^f Weiland et al. 2015, ^g Axel et al. 2010, ^h Hockersmith et al. 2010, ⁱ Beeman et al. 2010, ^j Skalski et al. 2013b, ^k Harnish et al. 2019, ^l Skalski et al. 2019.

E.3.3.1 Spill, travel time, and survival

The proportion of water spilled at each project and how it affects juvenile travel times and overall system survival has been extensively studied since the 2008 BiOp. Travel time through the system is an important consideration for direct survival for salmon and steelhead. It is also hypothesized by some parties to affect subsequent adult return rates. An investigation by Haeseker et al. (2012) identified correlations between spill and water travel time through the CRS and the rate of adult returns, as measured by SARs. They also found that higher juvenile fish survival through the CRS was associated with higher ocean survival. They suggested that increased spill and reduced water travel time through the CRS could provide more favorable river conditions that could further improve overall life cycle survival. However, their analysis examined fish passage data and average CRS spill from 1998 to 2006,

before the installation of most of the surface passage systems that have reduced travel time and made spill more efficient. That period was also prior to the implementation of the 2008 BiOp spill program.

In fact, fish travel time has notably decreased since the 2008 BiOp with the advent of spillway weir surface passage relative to prior BiOps. Comparisons of fish travel time since 2010, the year in which all dams finally had surface passage routes installed, show that fish travel time now remains similar across widely varying flow levels. One exception was migration travel times in 2015 (a very low flow year), when travel time for yearling Chinook and juvenile steelhead through the CRS fish-passage dams was longer than the average travel time from 2010–2018 but still shorter than the 2003–2007 average for most of the migration season. As in previous years, the difference between the 2003–2007 average and 2015 travel time was greater for steelhead than for yearling juvenile Chinook (Faulkner et al. 2016). This may indicate that juvenile steelhead, being more surface oriented, receive a greater benefit from surface passage routes than do yearling juvenile Chinook. In general, even in low flow years, such as 2015, fish travel times have improved, associated with the reduced forebay delay resulting from the combination of increased spill, spillway weirs, and other surface passage routes.

High spill levels can have unintended consequences for all life stages of fish and other aquatic biota. Season-long, system-wide spill levels to gas cap such as those ordered by the district court for the spring 2018 fish passage season are beyond the range of scientifically studied data, as were the projected spill level recommendations from Haeseker et al. (2012). These unintended consequences may include elevated levels of TDG causing gas bubble trauma in juveniles and adults, and delayed upstream passage of returning adult salmon and steelhead. Also, higher spill levels at low to medium river flow levels can create tailrace hydraulic conditions that may hinder juvenile fish egress downstream after passage at a given dam.

Uncertainty exists as to whether powerhouse passage (passage through the turbines or juvenile bypass systems) results in latent mortality of juvenile salmon and steelhead. As described above, the results of studies, using different methods during different time periods (before and after the overhaul of the system), have come to alternative conclusions.

E.3.3.2 Juvenile river reach survival estimates

In addition to tracking survival at the individual dams on the lower Snake and Columbia Rivers, the Action Agencies have monitored survival of juvenile fish over longer reaches of the river; for example, survival from Lower Granite Dam to Bonneville Dam has been measured in different forms since the mid-1960s.

The improvements in dam passage survival and reductions in fish travel time discussed above should have resulted in changes in juvenile fish survival detectable at the reach scale. This depends on whether the change is large enough to be detected relative to other factors that may affect survival each year, such as fish size, condition, and environmental variables. Since 1993, the availability of PIT tags, mass tagging of representative fish, installation of multiple detection systems, and the development of statistical models have enabled juvenile fish survival through the CRS reach to be standardized and estimated with greater precision.

While estimated survival varies among years and species, important patterns in the data stand out for both species (Figure E-6). First, the severe downward trend in survival observed in earlier decades has

been altered with increasing survival through the river reaches, which have been generally much higher since Endangered Species Act (ESA) listing in the early 1990s.

In-river survival through the CRS today is higher than it was in the 1970s. The 1970s represent a period when most CRS dams were in place and operating (the last, Lower Granite Dam, was completed in 1975), but significant improvements in passage conditions had not yet been made. It is important to recognize that any change in juvenile fish survival through the CRS is the result of the overall migratory conditions encountered, including the volume and timing of runoff, the suite of management actions implemented under the 2008 BiOp, the condition of wild fish and those released from hatcheries, and the degree of predation that migrating fish are exposed to each year.

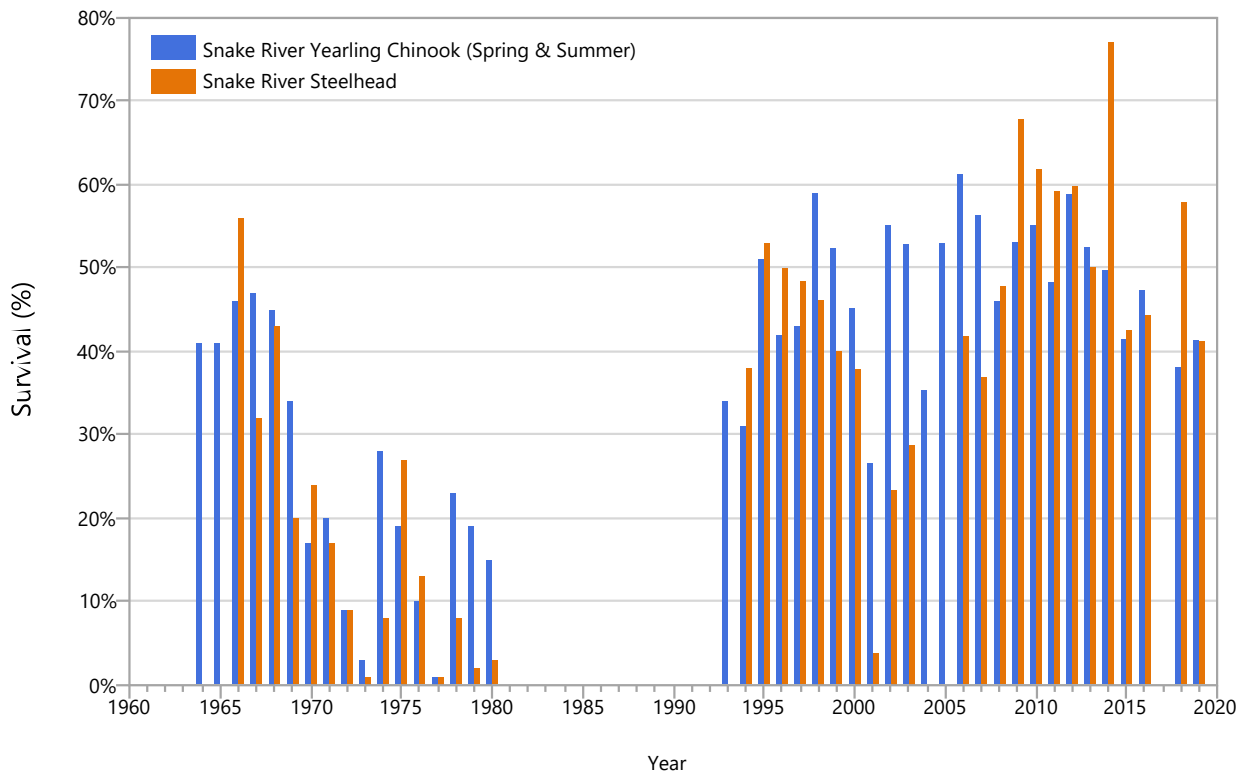


Figure E-6. In-river survival estimates (hatchery and wild fish combined) for Snake River (SR) Chinook and steelhead, from the trap above Lower Granite Dam to Bonneville Dam. Source: Widener et al. 2018 and 2019; Williams et al. (2001).

Two independent research groups estimate juvenile fish survival through dams and reservoirs on the lower Snake and Columbia Rivers; NMFS’s Northwest Fisheries Science Center (Science Center) (e.g., Faulkner et al. 2016; Widener et al. 2019) and the Comparative Survival Study (CSS) program (www.fpc.org; e.g., McCann et al. 2016; McCann 2018). Estimates by both groups are based on PIT-tagged fish released from hatcheries throughout the river basin or at traps at key locations in the migration corridor, and subsequently detected at one or more receivers while migrating downstream. PIT tag data are archived and made available to the research groups through the PIT Tag Information System.

The analyses generated by each group have different purposes and use different aggregates of fish groups in the estimates, making direct comparisons of the results challenging. In general, CSS estimates travel time and survival for both hatchery and wild-origin fish marked above Lower Granite Dam, and the Science Center uses a composite population for estimates, including fish marked at Lower Granite Dam. Since this review focusses on survival trends for the composite population, much of the review below is based on Science Center estimates of reach survival from Faulkner et al. (2016); Widener et al. (2019).

E.3.3.3 Post-2008 BiOp Snake River reach survival (Lower Granite to Bonneville)

SR SPRING CHINOOK AND STEELHEAD

Since the 2008 BiOp, annual Science Center natural and hatchery-origin Snake River salmon survival estimates from Lower Granite Dam to Bonneville Dam have ranged from 43 to 63 percent for yearling Chinook salmon, 42 to 76 percent for steelhead, and 12⁶ to 71 percent for sockeye salmon. Comparing annual estimated survival during the post-BiOp period (2008–2016) to the pre-BiOp period (beginning in 1997, 1998, or 1999, through 2007; varies by species) indicates that the relative mean estimated survival has increased for all species (Figure E-7). The mean estimated annual survival for each of the three species calculated by the Science Center for the post-BiOp period is 53.8 percent for Chinook salmon, 56.6 percent for steelhead, and 46.7 percent for sockeye (Figure E-7). Sockeye salmon (a 36 percent relative increase) and steelhead (a 57 percent relative increase) survival have increased more than for Chinook salmon (a 4 percent increase). However, Chinook salmon already experienced a relatively high mean estimated survival through the system before the suite of actions under the 2008 BiOp.

⁶ Early hatchery practices failed because of water quality differences between the hatchery and release sites (Trushenski et al. 2019).

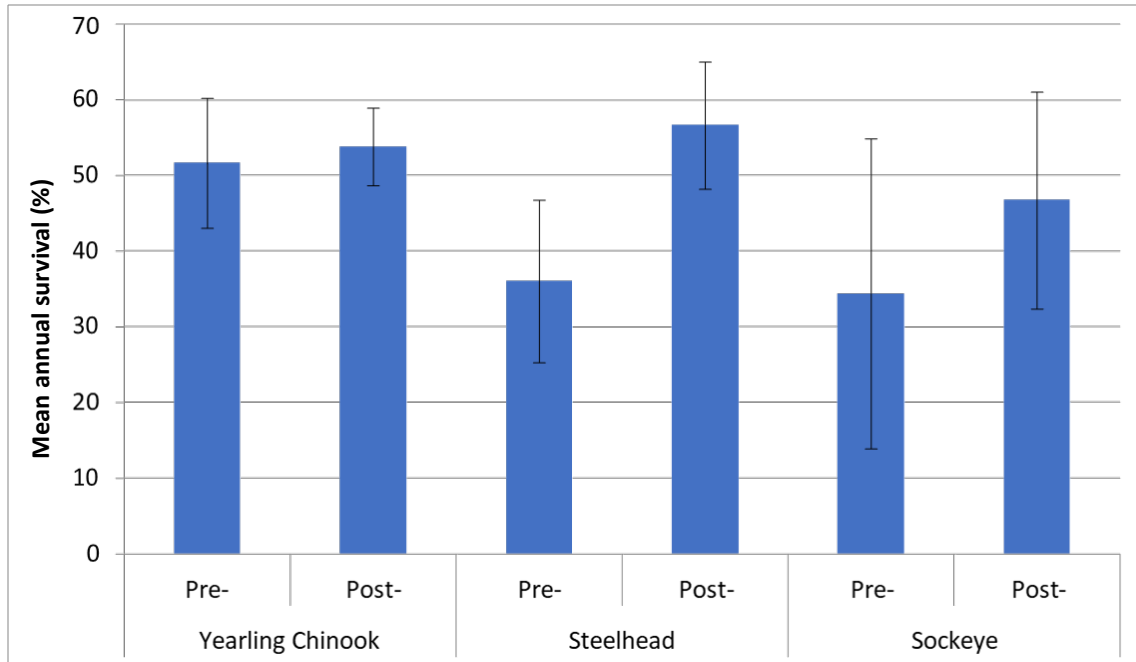


Figure E-7. Estimated mean annual survival of hatchery and wild fish (with whiskers representing 95 percent confidence intervals) from Lower Granite Dam tailrace to the Bonneville Dam tailrace in pre-BiOp (1996–2007) and post-BiOp (2008–2016) time periods. (Note: Data were obtained from Faulkner et al. 2016, as well as personal correspondence with Faulkner, April 10, 2016. Data include hatchery- and wild-origin fish.)

According to Faulkner et al. (2016), annual reach survival for yearling Chinook salmon have remained relatively stable since 1999, with the exception of 2001, 2004, and 2015, which were all lower-flow water years and 2015 water temperatures were considerably high. The increase in steelhead survival since 2001 (a severe drought year) is notable. In 2001, most fish were transported around dams and the few fish remaining in the river were likely preyed upon heavily. Steelhead survival through the eight Columbia and Snake River fish passage dams was approximately 4 percent that year (Faulkner et al. 2016) (Figure E-8).

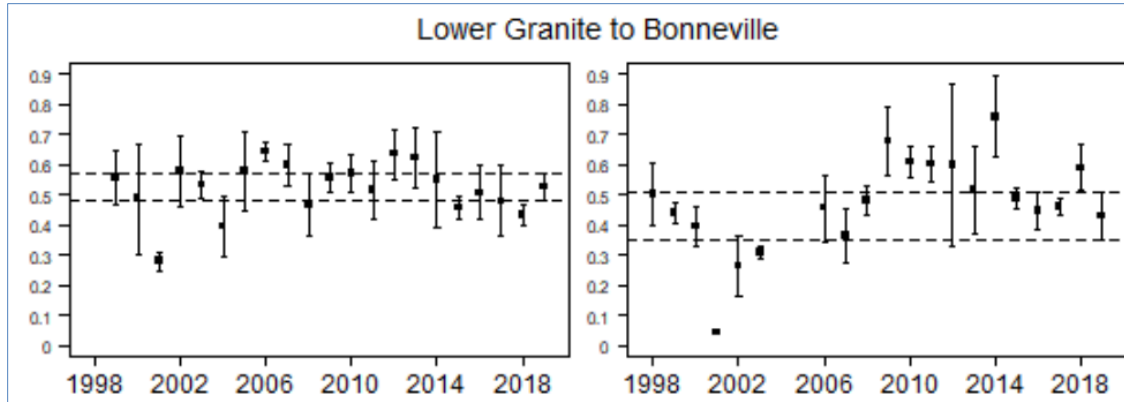


Figure E-8. Annual average survival probability estimates for PIT-tagged SR yearling Chinook salmon (left) and steelhead (right) (hatchery and wild combined) from Lower Granite Dam to Bonneville Dam, 1998–2019. Estimates are from tailrace to tailrace. Vertical axis runs from 0 to 0.9 probability. Vertical bars represent 95 percent CIs. Horizontal dashed lines are 95 percent CI endpoints for 2019 estimates. Figure from Zabel (2019).

Relatively high reach survival for yearling Chinook salmon and steelhead since the 2008 BiOp may be related to the operation of surface passage structures at dams (Hockersmith et al. 2010; Axel et al. 2010; Plumb et al. 2003). Surface passage structures such as spillway weirs particularly benefit juvenile steelhead, which tend to be more surface oriented during migration. Most recently, lower-than-average spill discharges in 2015 may have reduced some benefit of surface passage structures in expediting fish passage (Faulkner et al. 2016). However, the observed in-river survival in 2015 increased compared to other historical low-flow and drought years, such as 2001 and 2004, which may reflect improved passage efficiency since the 2008 BiOp.

SR SOCKEYE SALMON

The ability to estimate survival for sockeye salmon depends on detection rates and numbers of fish tagged each year. Over the last decade, there has been an increased effort to PIT tag upper Columbia and SR sockeye, which resulted in sufficient data available for annual estimates of survival for SR sockeye salmon. The long-term (1998–2019) mean estimated sockeye survival rate from the tailrace of Lower Granite Dam to the tailrace of Bonneville Dam is 40.7 percent, although with considerable year-to-year variation with 2018 having one of the highest survival rates (64.3 percent) (Widener et al. 2019). Despite the increased tagging efforts, the detection rates of these fish remain low because of the increasing use of surface passage routes where fish are not detected. This decreases the precision of survival estimates. At present, we can only assume sockeye salmon survival is dependent on factors similar to those affecting survival of yearling Chinook salmon and steelhead.

While the survival probability estimates above were for wild-and hatchery-origin fish combined, Widener et al. (2019) also provided separate estimates for wild fish and for hatchery fish. While the patterns in survival are similar to those reported for wild and hatchery combined, wild yearling Chinook salmon fared slightly worse than the combined group, with 48.1 percent (versus 52.1 percent) average survival over the 1999–2018 period. Over the same period, wild steelhead showed the same trend, with 42.8 percent average survival (versus 47.2 percent for wild and hatchery combined).

E.3.3.4 Columbia River reach survival – McNary to Bonneville

UPPER COLUMBIA RIVER (UCR) SPRING CHINOOK AND STEELHEAD

The Science Center has calculated survival estimates of hatchery-origin yearling Chinook salmon and steelhead migrating from the upper Columbia River through the four lower Columbia River fish-passage dams since the late 1990s (Widener et al. 2019). The annual estimated survival of upper Columbia River hatchery-origin yearling Chinook salmon between McNary Dam and Bonneville Dam has averaged approximately 81.4 percent since 1999, ranging from 62 to nearly 100 percent because of high standard errors in the lower Columbia River estimates (high standard errors can be attributed to low PIT tag detection efficiencies at and downstream of Bonneville Dam).⁷

Annual survival estimates of hatchery-origin steelhead averaged 74.7 percent since 2003, and have ranged from approximately 49 to nearly 100 percent, also because of high standard error is survival estimation. Though Faulkner et al. (2016) did not break out upper Columbia hatchery and wild sockeye salmon, the combined estimated survival from McNary Dam to Bonneville Dam tailrace was higher for sockeye originating in the upper Columbia River Basin (54.5 percent) than for those from the Snake (22.7 percent), and the difference was statistically significant. This trend reversed in 2018 with survival of sockeye salmon originating in the upper Columbia River Basin having lower survival (56.0 percent) than for those from the Snake River (94.0 percent) (Widener et al. 2019). The trend reversal is likely a direct correlation in changing hatchery practices for sockeye on the Snake River, which have resulted in increased smolt survival through the hydrosystem.

E.3.3.5 Reach survival comparisons to COMPASS

Under the 2008 and 2019 BiOps, the Action Agencies monitored in-river reach survival for SR and UCR Chinook salmon and steelhead and reported the results annually. The BiOps call for the Action Agencies to measure in-river survival empirically over two reaches; Lower Granite Dam to Bonneville Dam and McNary Dam to Bonneville Dam. The results are then compared with the survival estimates derived from COMPASS modeling that incorporates improvements implemented under the BiOp. COMPASS is a Comprehensive Passage model developed under NMFS' leadership to predict the effect of alternative dam operations on salmon survival rates. The model is designed to simulate survival and travel time through the CRS under various river and operational conditions and can simulate the effects of different management actions, producing results that agree with available data.

For the most recent comparison for the 2015 migration season, the COMPASS model was run for the actions implemented at the start of the 2015 migration season using 2015 river conditions, fish migration patterns, and dam and transport operations (Figure E-9).

⁷ For practical purposes, these estimates should be considered equal to 1.0 and to represent true survival probabilities that are certainly less than 1.0 by some amount.

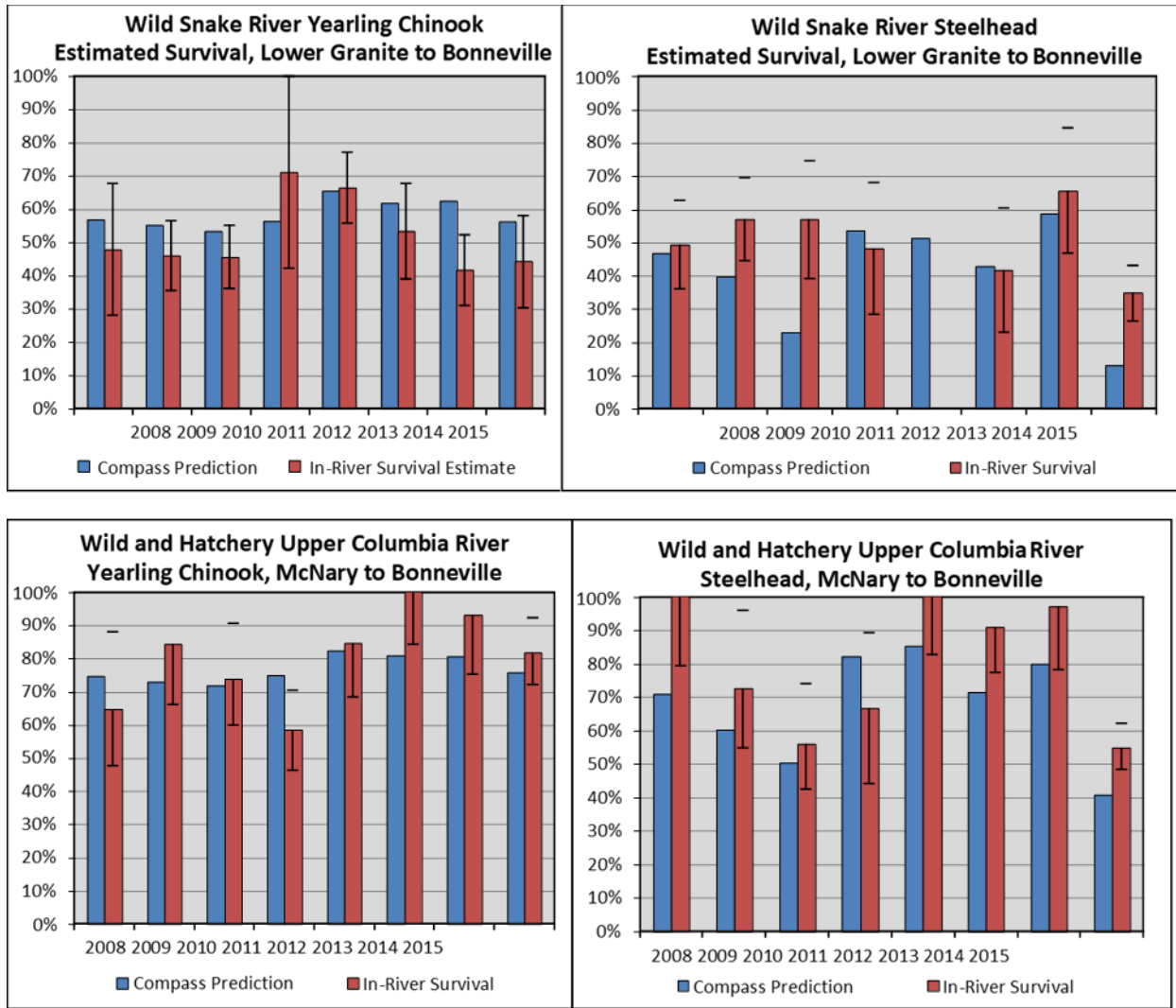


Figure E-9. 2008–2015 COMPASS model predictions and PIT tag estimated in-river survival for juvenile SR wild spring/summer Chinook and steelhead and for UCR wild/hatchery spring Chinook and steelhead. Error bars indicate 95 percent confidence intervals. PIT estimate not available for wild SR steelhead for 2012. Source: Widener et al. 2018.

The results presented in Figure E-9 indicate the benefits from improved system operations, passage improvements, and predation deterrent actions implemented to date are generally accruing at least as well as was expected in the 2008 BiOp analysis.

E.3.3.6 Water management and flow

In addition to the dam-passage improvements discussed above, system-wide actions to improve conditions in the migration corridor have been implemented. These include flow augmentation and water management actions to shape flows to benefit the fish. These actions were initially designed to move fish downstream faster and limit their exposure to instream predators. These actions also assist juvenile fish in reaching marine waters when they can take advantage of optimum forage conditions and

best avoid ocean predators. Scheuerell et al. (2009) analyzed data from more than 40,000 individually tagged yearling Chinook salmon and steelhead detected at Bonneville Dam on their downstream migration and at Lower Granite Dam when they returned as adults. Scheuerell et al. (2009) found that juveniles migrating from early to mid-May survived to return as adults at rates 4 to 50 times greater than those migrating in mid-June. They also found that the precise peak in SARs varied among years, presumably reflecting variations in ocean conditions from year to year.

While one of the multiple authorized purposes of the CRS projects is to manage flood risk, flow augmentation to enhance migratory conditions for juvenile and adult salmonids in the mainstem lower Snake and Columbia river is important. In the upper Columbia River (downstream from Chief Joseph Dam), flow augmentation is available from upper basin storage reservoir projects in the CRS, such as Grand Coulee Dam, Hungry Horse Dam, Albeni Falls Dam and Libby Dam, as well as other storage reservoirs in Canada. In the Snake River, river flows can be augmented using releases from Dworshak Dam, a storage project on the North Fork of the Clearwater River, as well as from releases from the non-federal, Idaho Power-owned Brownlee Dam in the Hells Canyon Complex.

The foundation for flow augmentation measures was initially based on the following two premises (Giorgi et al. 2002):

1. Increased water velocity → increases migration speed of smolts → increases survival.
2. Lowering water temperature (summer) → improves migratory and rearing conditions for both juvenile and adult salmonids → improves survival.

Flow augmentation actions strive to meet multiple ecosystem objectives, including improved flows for anadromous fish; state and federal water quality standards that currently limit TDG concentrations; flow needs for other listed resident fish such as Kootenai River white sturgeon and bull trout; state and federal water quality standards for temperature; and reservoir refill for flow augmentation in subsequent years. Water management actions must also consider ecosystem needs as well as other public uses, including flood control, irrigation, recreation, and power system management.

Hydrologic conditions in the Columbia River Basin vary among and within years and are primarily driven by the total amount and form of precipitation and the runoff pattern. This variability greatly influences CRS operations and requires a process for coordinating pre-season and in-season water management decisions. The CRS storage projects are operated in conjunction with Canadian projects to use the available stored volume and predicted runoff for the needs discussed above (Figure E-10).

The flow objectives cannot physically be met every year given the limited storage capacity in the CRS. The objectives serve as benchmarks, however, which are used to guide real-time water management decisions and maximize benefits for migrating salmon given annual conditions and stored water volumes.

COOL WATER RELEASES FROM DWORSHAK DAM

During summer, when ambient river temperatures are high, flow augmentation is used to help moderate temperatures in the lower Snake River by releasing water from Dworshak Dam on the Clearwater River. This action primarily benefits juvenile fall Chinook salmon that rear and migrate in the lower Snake River during summer.

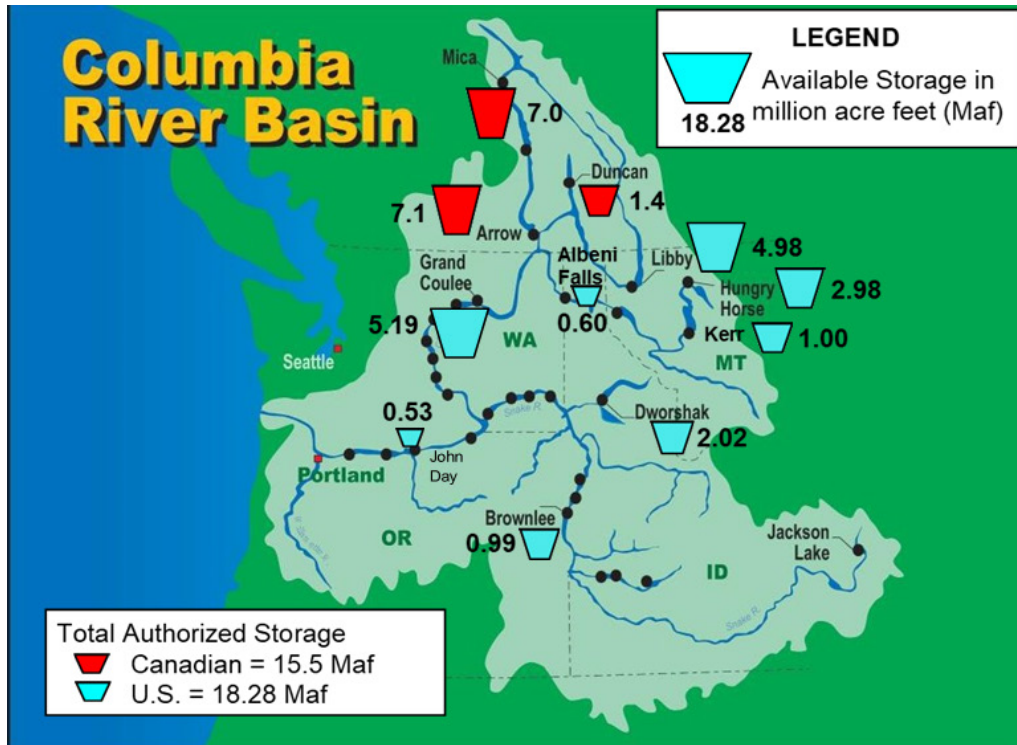


Figure E-10. Active storage volumes at reservoirs in the Columbia River Basin

The release of cool water from Dworshak Dam also benefits adult sockeye, steelhead, and fall Chinook migrating during summer. In 2015, low snow pack 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. Recommendations from a NMFS review of river conditions in 2015 focused on continuing beneficial operations such as the cool water releases from Dworshak Dam, and where possible, improving migration conditions for adult sockeye salmon, which experienced heavy losses in the Columbia River and tributaries (NMFS 2016).

LOWER SNAKE RIVER AND LOWER COLUMBIA RIVER RESERVOIR OPERATIONS

Since 1995, Snake River projects have been operated within 1 foot of minimum operating pool (MOP) and John Day Dam has been operated within 1.5 feet of minimum irrigation pool (MIP), with the goal of reducing the cross-sectional area of these reservoirs, thereby reducing fish travel time. MOP refers to a project's lower operating range (the level below which fish facilities are no longer operational), while MIP refers to the minimum level at which irrigation systems can effectively access water. The rationale for these operations was based on a hypothesis that reducing reservoir volume would expedite juvenile migration (Raymond 1979; Sims and Ossiander 1981; Giorgi et al. 2002).

However, under the current configuration of the eight lower river dams (e.g., with surface passage facilities) and performance-standard-based spill operations, fish travel time does not appear to change under different river flow conditions. Given the volume of the reservoirs, there would be very little difference in the velocity of the river with a 6-inch increase in reservoir elevation; this would also have

negligible impacts on overall reservoir water temperature. The Action Agencies have reviewed previous water temperature modeling efforts and have not found any empirical information that would signal cause for concern regarding water temperature effects. The effects of alternate reservoir elevations will be reconsidered using updated water quality models that will be developed as part of the ongoing NEPA alternative analysis of CRS operations.

Since 2008, there has been a wide range in annual flow conditions experienced in the CRS. For example, 2011 was a relatively high flow year, while 2015 was one of the lowest flow years on record. It is instructive to compare fish travel time between these high flow years and low flow years, as well as to compare similar flow years prior to 2008 with post-BiOp spill operations and configurations (e.g. 2001 compared to 2015). For Chinook, travel time for yearling Chinook and juvenile steelhead through the CRS during the spring of 2015 was shorter than the 2003-2007 average for most of the migration season as noted previously (Zabel 2019) (Figure E-11).

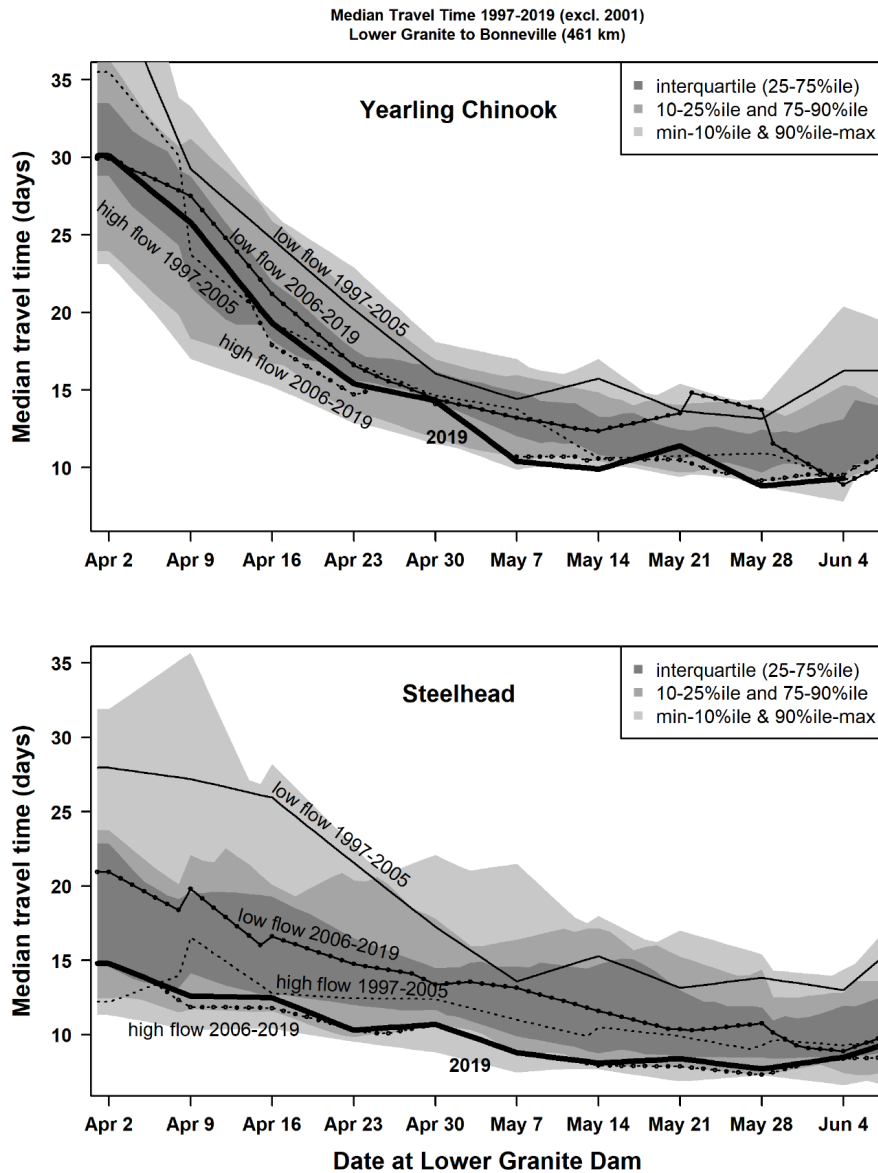


Figure E-11. Median travel time from Lower Granite Dam to Bonneville Dam for weekly groups of yearling Chinook salmon and steelhead. Shaded regions show daily quantiles during 1997–2019 (excluding 2001). Lines show daily medians from low- and high-flow years by spill regime, with low-flow years for the former (2004–2005) and present regime (2007, 2010, 2013, and 2015) and high-flow years for the former (1997 and 2006) and present regime (2011, 2012, 2017, 2018, and 2019). Source: Zabel 2019.

Zabel (2019) evaluated fish travel time patterns within the outmigration season each year and concluded that the observed decreases in travel times for yearling Chinook salmon and steelhead later in the spring passage season generally coincided with increases in flow, and presumably with increased levels of smoltification (Figure E-12). The fish benefits of flow augmentation or reservoir management alone cannot be estimated empirically because juvenile fish migrations are affected by multiple factors

simultaneously (e.g., climate, hydrology, and smolt characteristics such as the degree of smoltification and fish size).

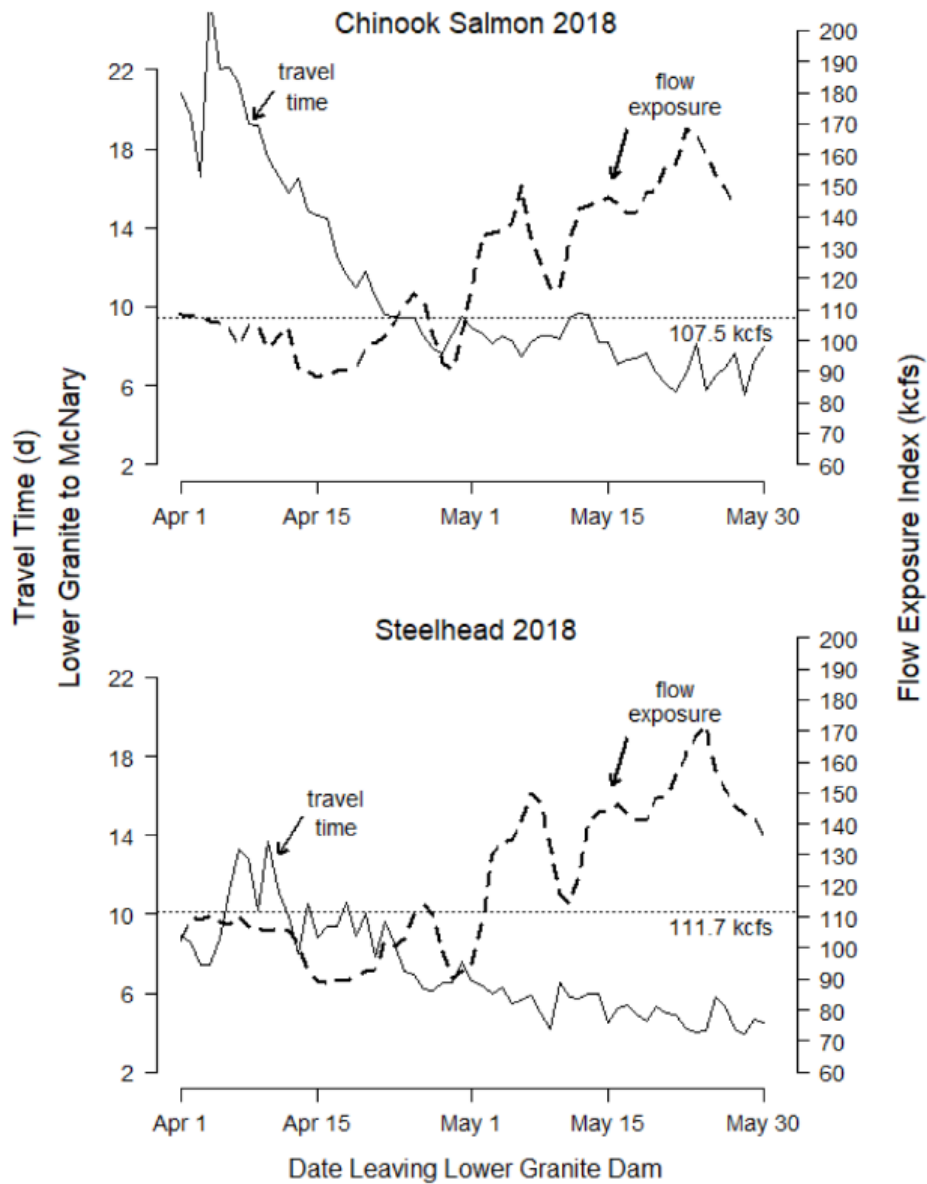


Figure E-12. Travel time (days) for yearling Chinook salmon and steelhead from Lower Granite Dam to McNary Dam and index of flow exposure at Lower Monumental Dam (kcfs) for daily groups of PIT-tagged fish during 2018. Dashed horizontal lines represent the annual average flow exposure index, weighted by the number of PIT-tagged fish in each group. Source Widener et al. 2019.

In the 2016 CSS annual report, McCann et al. (2017) used a model-based approach to assess the effects of environmental variables such as flow and spill, and found that fish travel time was most correlated to flow-based water travel time and spill. They posited that “the effect of [water travel time] most likely influences the amount of time required to transit the reservoirs, with faster [water travel time] resulting in faster fish travel time through the reservoirs.”

More recent data presented by the CSS suggests that the highest smolt-to-adult return (SAR) ratios may be associated with lower flow years (McCann et al. 2018) (Figure E-13). This effect is likely driven by CSS analysis, which shows that powerhouse passage (a key factor for juvenile survival and adult returns in the CSS model) is lowest under low flow conditions, when spill passage efficiency is greater than under moderate or high flows. Similarly, the modeled estimates of SARs under various flow conditions are estimated to be highest across the board with lower flows (Figure E-14).

Both groups, NMFS and CSS, have investigated relationships between flow and fish travel time and prior to implementation of the structural and operational improvements called for in the 2008 BiOp, flow augmentation and reservoir operations were targeted to increase migration speed of smolts.

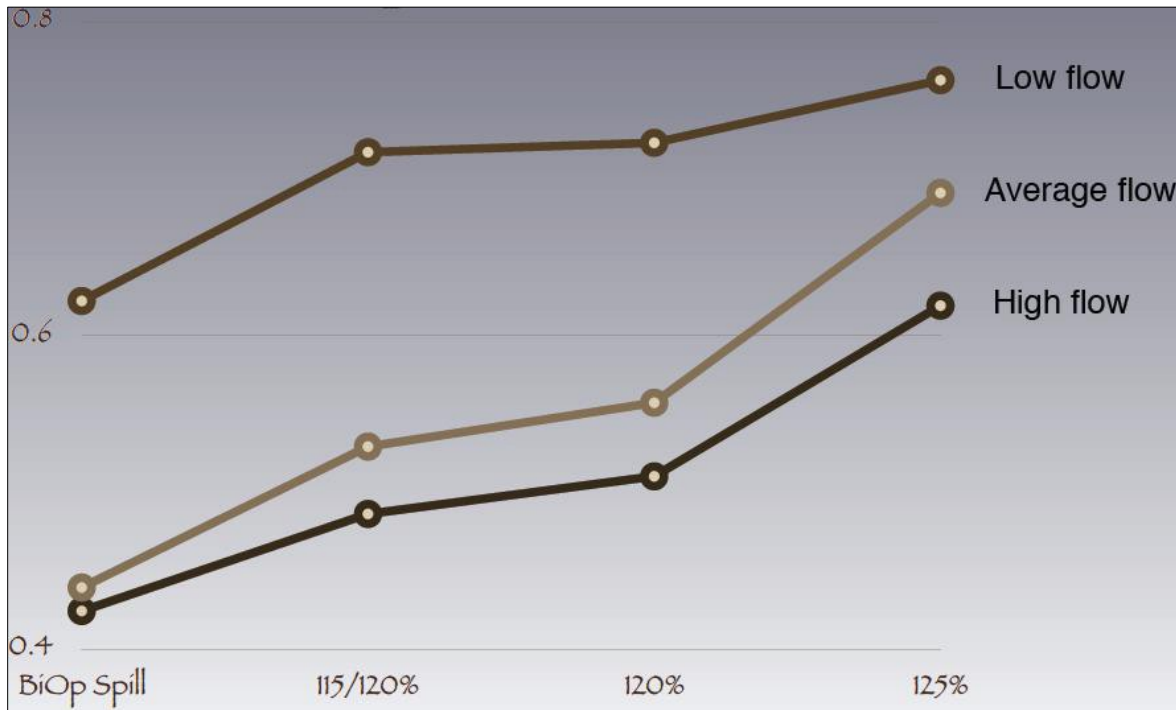


Figure E-13. In-river migration survival (McCann et al. 2017)

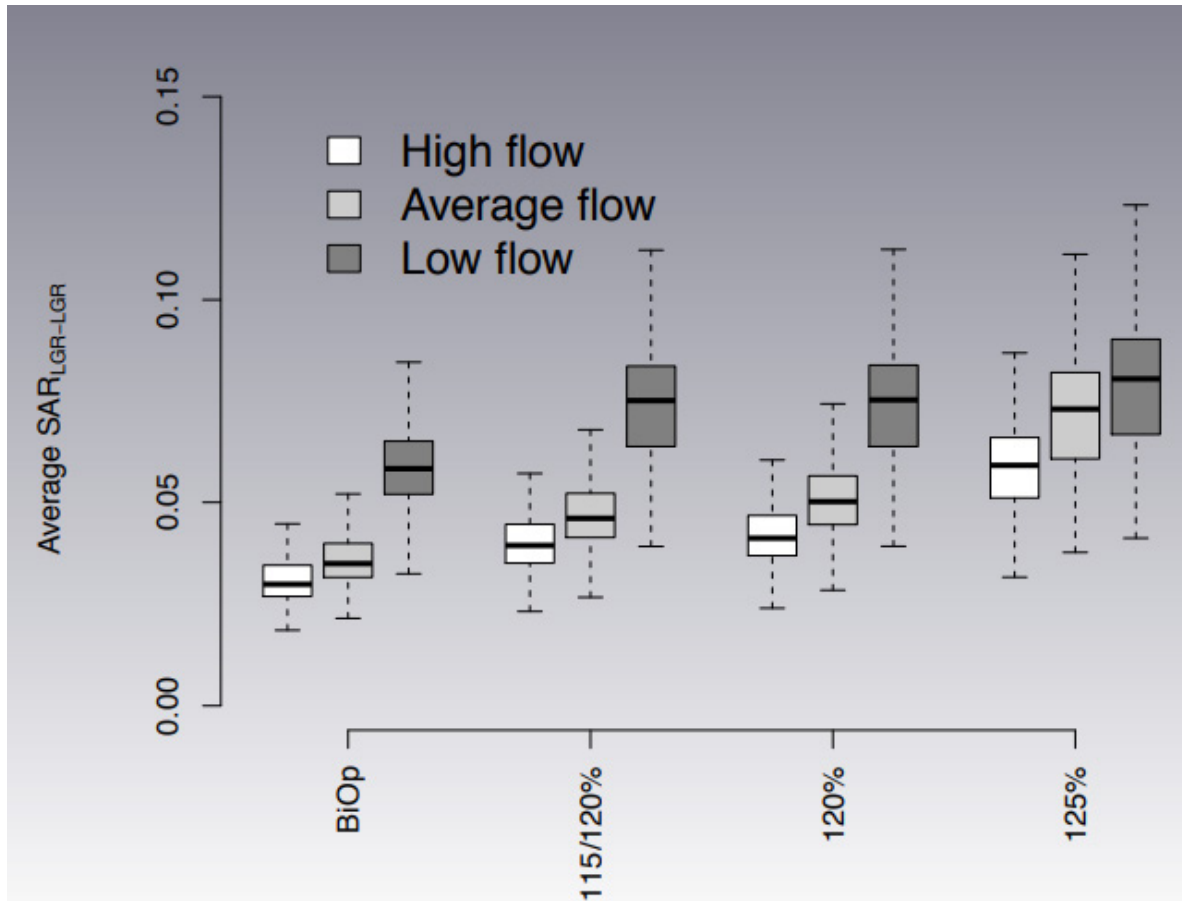


Figure E-14. SAR (measured by downstream migrants detected at and returning to Lower Granite Dam) at low, average, and medium flow years during four modeled spill operations: (1) 2008 BiOp, (2) injunction gas cap spill 120 percent TDG tailrace and 115 percent TDG forebay, (3) gas cap spill in tailrace of 120 percent TDG and (4) gas cap spill in tailrace of 125 percent TDG (McCann et al. 2018).

Monitoring reported by NMFS (Faulkner et al. 2017) shows that under the current configuration of the CRS, fish travel time does not appear to be influenced to the same degree by changes in water velocity compared to pre-2008 BiOp conditions. While differences in travel time have been noted, the effect of flow on other aspects of juvenile survival and adult return rates cannot be dismissed. The effects of flow on the energy expended by juveniles during their migration is likely higher under low flow conditions. Flow can also affect the position of predators in the juvenile migration corridor, affect the near shore habitat available for juvenile fish, affect the turbidity of the water, and affect the flux of prey from inundated nearshore habitat into the migration corridor. All of these actions are deemed beneficial to juvenile survival as they migrate through the CRS.

E.4 THE QUESTION OF LATENT MORTALITY

Latent mortality remains one of the key uncertainties surrounding the operation of the eight fish passage dams on the lower Snake and lower Columbia Rivers. Reducing the uncertainty surrounding the question of whether latent mortality occurs as a result of dam passage, as well as its magnitude, and

identifying any causal mechanisms, are key drivers behind the Action Agencies Proposed Action for the 2018 BiOp.

Juvenile fish passing through the eight dams in lower Snake and Columbia Rivers may experience stress or other impacts that result in mortality at some point after they pass the dams, a concept that has been termed “delayed” or “latent” mortality. The theory behind latent mortality, first proposed by Schaller et al. (1999) and Deriso et al. (2001), is that salmon and steelhead that migrate through the bypass systems are harmed in some manner that is not directly observable, before they enter the estuary (where physical monitoring occurs). Numerous studies have been conducted with tagged fish to estimate survival through the bypass systems relative to other passage routes. Estimates of direct survival (to a short distance below the dam) from recent studies for yearling Chinook Salmon and steelhead ranged from 90 percent to 100 percent across eight dams, with a mean of 97 percent (Axel et al. 2008; Beeman et al. 2008; Ploskey et al. 2011, 2012; Skalski et al. 2013a, 2013b; Weiland et al. 2013, 2015). Although direct passage survival through bypass systems is relatively high, proponents of this theory suggest that this harmful passage experience through the bypass system manifests in a delayed response, at some point after those fish enter the ocean, resulting in substantially lower adult return rates than would have occurred had those same fish migrated through spillway passage routes instead.

The effect is often assessed by comparing the SAR rate of groups of fish that experience different passage conditions. The comparisons of SARs can be complicated by other variables as well, such as ocean conditions and toxics in the freshwater migratory corridor, among other factors, which significantly influence life-cycle survival.

Whether latent mortality occurs as a result of dam passage route, as well as its magnitude and causal factors, have been debated for at least two decades, and investigations have produced conflicting results. The Independent Science Advisory Board (ISAB) has considered the topic of latent mortality many times and has continued to advise the region on efforts to understand more fully the effects of passage through the eight fish passage dams and whether any latent mortality is attributable to how the Action Agencies manage water through the system.

In 2006, NMFS requested that the ISAB review a number of hypotheses explaining the effect and causative factors thereof. The ISAB concluded that the CRS causes some latent mortality, but strongly advised against continuing to try to measure absolute latent mortality, because it is not measurable relative to a pre-dam reference condition. Instead, they suggested the focus should be on the total mortality of in-river migrants and transported fish, which is the critical issue for recovery of listed salmonids (ISAB 2007).

In 2012 the ISAB again concluded that bypass systems are associated with some latent mortality, but cautioned that “the factors responsible for latent mortality remain poorly understood and inadequately evaluated” (ISAB 2012). The ISAB said the mortality may reflect a tendency for smaller and more vulnerable fish to pass through bypass systems, in which case the mortality could be related to fish condition rather than the effects of bypass systems themselves.

In their reviews of proposals intended to test the magnitude of latent mortality through alternate spill operations, the ISAB in 2014 and 2017 continued to advise the region to address study design elements to increase the likelihood that levels of spill could be isolated as a causative factor rather than a correlative influence on adult return rates (ISAB 2014, 2018).

E.4.1 Ongoing latent mortality research

Since the ISAB first offered its initial synthesis of latent mortality studies, several research groups have continued to delve into aspects of latent mortality hypothesized to be associated with in-river migration. Focal topics have included the effects of screened bypass systems, general migratory conditions in the CRS, and the number of hydroelectric projects, particularly powerhouses, encountered. The effect is often assessed by comparing the survival of groups of fish that experience different passage conditions.

Earlier investigations focused on the impacts of screened bypass systems designed to divert fish away from turbines. Sandford et al. (2012) held juvenile fish in tanks for approximately 7 months following their downstream migration through the CRS but did not detect higher mortality among fish that had passed through more bypass systems. However, an analysis of 11 years of PIT-tag data by Buchanan et al. (2011) found that the more bypass systems Chinook smolts passed through, the lower the rate they returned as adults. Steelhead smolts showed similarly reduced returns after passing through two or more bypass systems. Another analysis by Rechisky et al. (2013) used acoustic tags to track two groups of hatchery fish through their downstream migration and their first month in the ocean. They found no difference in survival between juvenile fish that migrated through eight dams and others that migrated through only four. Likewise, a 7-year NMFS study (2005–2011) compared survival rates of SR spring/summer hatchery chinook which passed eight dams vs. those trucked below Ice Harbor (five dams). The study found no significant delayed mortality effect, but observed significant variation among years for the relative SARs between the in-river and trucked groups (Marsh et al. 2015). Some have questioned the validity of comparisons between different hatchery stocks and the limited period the fish were monitored in the ocean in these studies.

Recently, latent mortality research has focused on effects of “powerhouse passage” on subsequent adult returns. (Powerhouse passage refers to passage through the bypass systems and turbines, and until recently, apparently included sluiceway routes at The Dalles and Bonneville PH1 as well, though that oversight was brought to the CSS researchers’ attention by the federal agencies in 2017). The CSS has developed several metrics to track the rate of powerhouse encounter rates. These metrics were originally based on the number of fish passing through the powerhouse on the proportion of flow moving through the powerhouse (NPH) and were then refined using PIT detection histories (PITPH).

Powerhouse passage, whether through turbines or screened bypass systems, is hypothesized by the CSS to reduce subsequent SARs. This hypothesized relationship has led to several calls by CSS and its proponents for experimental spill operations since 2014. These proposals called for further increases in spill levels above those provided under the 2008 BiOp in an effort to increase the number of fish using non-powerhouse routes (increased use of spillways and sluiceways). The CSS has estimated that increasing spill from 2008 BiOp levels to the current state water quality standards of 115 percent/ 120 percent TDG levels could lead to approximately a 20 percent increase in SR Chinook SARs (CSS Oversight Committee 2017). It is unclear what the CSS’s predicted increase in Columbia River stocks would be under a higher spill cap operation.

In 2014, based on the CSS hypothesis, some regional parties asked for a spill operation higher than legal TDG levels, up to 125 percent. These requests were made to the Northwest Power and Conservation Council as the Council prepared their 2014 Fish and Wildlife Program and to NMFS as they developed the 2014 Supplemental BiOp. The Council asked the ISAB to review the proposal, which informed both

groups as they finalized the Fish and Wildlife Program Amendments and the 2008 BiOp. When responding to comments on its 2014 BiOp, NMFS noted that there was too much uncertainty in the CSS hypothesis to justify the risk of unintended consequences of an operation to 125 percent. The ISAB's report that was released the following month reached a similar conclusion. In its review of the 2014 proposal to spill to 125 percent TDG, the ISAB noted among other issues:

1. The correlation observed in the CSS modeling between high spill levels and increased SARS is not necessarily the result of a causal relationship.
2. the potential for many unintended consequences to juvenile and adult salmon that must be considered;
3. the challenge of isolating a change in SARs associated with changes in spill levels from many competing factors, such as ocean conditions;
4. the need for an improved study design.

In 2017, as noted above, the CSS Oversight Committee submitted additional information to the ISAB to attempt once again to justify the need for spill levels above the 2008 BiOp spill program. The updated CSS modeling shows that the average powerhouse encounter rate has declined by more than 50 percent since the early-1990s (Figure E-15). The CSS models predict that further reductions in PITPH will significantly increase SARs depending on spill levels. Under 2008 BiOp spill levels and the current CRS configuration, powerhouse passage rates for Snake River average slightly less than two out of eight dams in low flow conditions and nearly three out of eight dams under average to high flow conditions. Under spill operations to the gas cap legal limits of 115/120 percent TDG, that powerhouse encounter rate is predicted to drop to just under one powerhouse encounter on average in low flow conditions and around two powerhouse encounters under average to high flow levels. This reduction of one powerhouse encounter is currently predicted by the CSS to improve SARs by approximately 20 percent. Further reductions in PITPH that may occur as a result of spill levels beyond the legal limits are predicted to reduce PITPH to less than 0.5 and are predicted to result in SARs that are 80 percent higher than the BiOp spill program. These predictions by the CSS have varied since 2014, sometimes substantially.

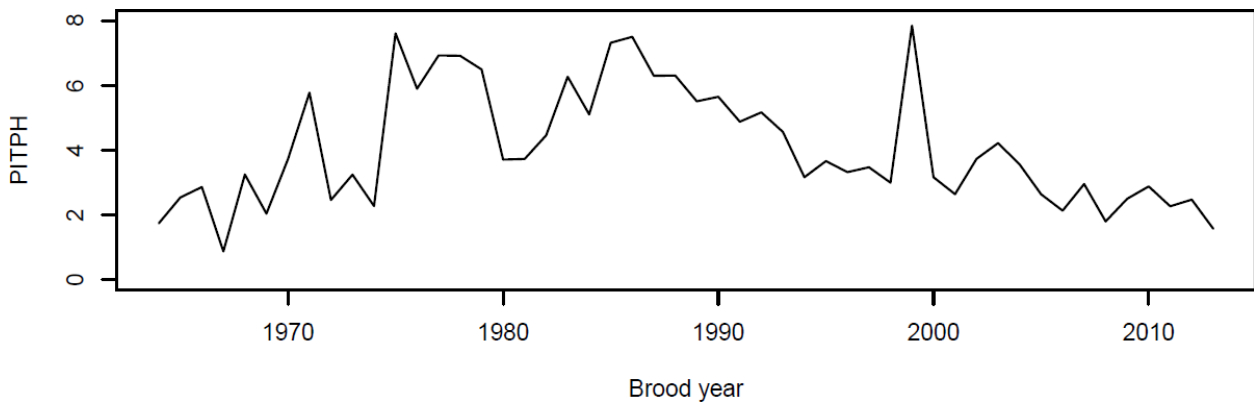


Figure E-15. Estimates of powerhouse passage rates (PITPH) used in CSS modeling. (From Figure 2.1 in McCann et al. 2017)

Given the uncertainty surrounding the CSS predictions of potential benefit, however, as well as the many concerns that NMFS scientists and the Action Agencies continue to have regarding the transparency and accuracy of the CSS modeling, additional research and regional discussion appears to

be warranted before the CSS hypothesis can reasonably be accepted as a basis for a permanent change in CRS operations that affect residents through four western states and beyond.

The Action Agencies plan to continue to work with regional stakeholders to develop a test that will help elucidate some of the remaining critical uncertainties surrounding the issue of latent mortality, including evaluating whether the CSS-hypothesized benefits to SARs, in-river survival, and fish travel time materialize. This research effort will include a defined hypothesis to test and will identify expected levels of power to determine a difference between performances-standard-based and gas cap spill operations while reducing the associated potential for making Type II statistical errors. It will be a challenge to determine a definitive answer as to whether gas cap spill, and a subsequent reduction in the number powerhouse encounters, has a meaningful effect on SARs. The Action Agencies have documented many of the challenges associated with isolating a change in SARs to system operations like varying levels of spill. In addition to the challenges of detecting a difference and attributing that difference to increased spill levels, a high spill operation at all eight fish passage projects will also result in a reduced number of transported fish during times when transport has shown to be beneficial, and increased system-wide TDG loading with unknown effects on migrating salmon and steelhead and other aquatic species in the river.

NMFS developed an analysis of SARs (see Figure E-16) of fish returning to Bonneville Dam based on the mean number of bypass passage events. Contrasting with the CSS model results, this analysis by NMFS did not show a significant effect.

Points:

1. SARs from 2011 migrants were very low (<0.5 percent) in a high flow / high spill year
2. SARs in 2006, 07, and 2010 were about the same, even though the estimated mean number of bypass was much lower in 2010 than in the other 2 years.

In addition to the CSS modeling and associated predictions of the effects of changes in CRS operations, several researchers, including work by Faulkner et al. (2019) and Hostetter et al. (2015) reported results suggesting that juvenile bypass facilities may selectively collect smaller, younger, or poorer condition individuals, with independently lower overall probabilities of survival. Faulkner et al. (2019) analyzed the database of PIT detections among spring-summer Chinook and steelhead at bypasses and ladders at the eight lower Snake and lower Columbia dams, including only juveniles that had fork length recorded at time of tagging. Among the seven dams (not including The Dalles Dam) where juvenile detection is possible at the bypass systems, the study found that larger fish had lower bypass probabilities, with Lower Granite and Bonneville Dams being the exception and could be an artifact of low sample sizes (Faulkner et al. 2019). Each dam displayed a different level of size selectivity for yearling Chinook salmon and steelhead. After accounting for juvenile length at tagging, bypass history had a low association with adult return rates because larger fish had a higher rate of return. Likewise, the work by Hostetter et al. (2015) yielded results suggesting that the hypothesis raised by ISAB may still be valid—that juvenile bypass facilities may selectively collect smaller, degraded individuals with lower probabilities of survival, such that the passage route may be purely correlative, not a causal factor in subsequent mortality in the ocean.

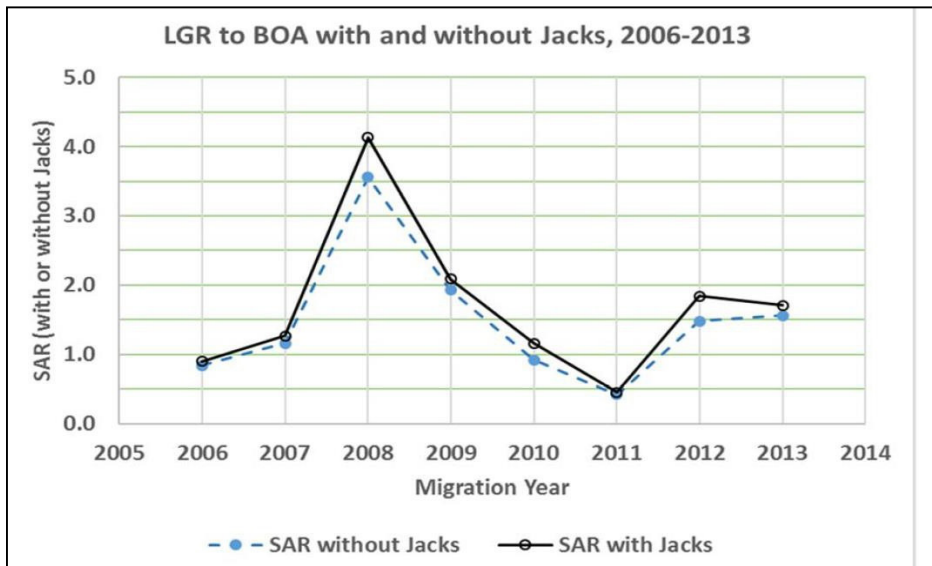
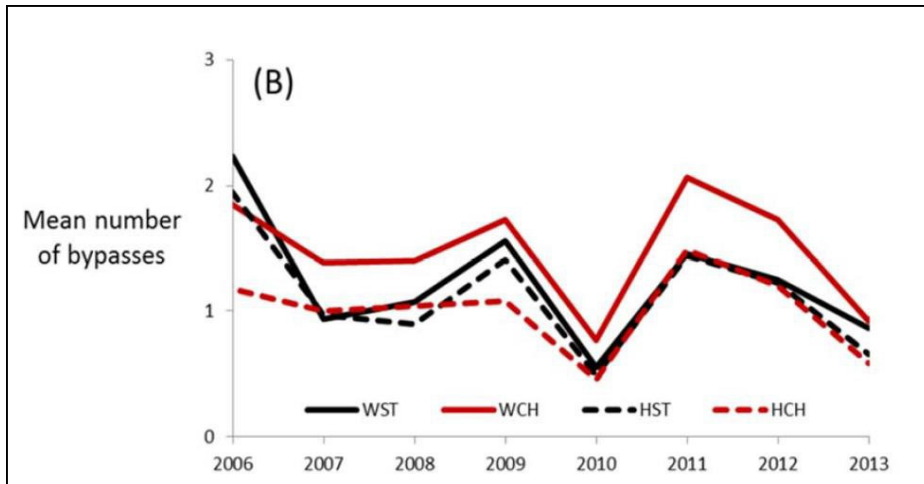


Figure E-16. TOP: Estimated Mean Number of Bypasses upstream of Bonneville Dam (solid red line is wild yearling Chinook. (Source: Graves declaration Appendix 2, page 40.) BOTTOM: Estimated SARs from Lower Granite to the ocean and back to Bonneville Dam with and without jacks.

As discussed in the previous version of this report, bypass systems that selectively pass smaller fish could be an alternate source of any apparent latent mortality and rather than powerhouse passage rates, fish size and condition may contribute to the appearance of latent mortality the CSS authors have observed in their models (Zabel et al. 2005; Hostetter et al. 2015). Faulkner et al. (2019) hypothesized that there may be two general mechanisms by which bypass size selectivity could be explained: (1) the vertical distribution of fish as they approach a dam and the physical ability of fish to escape the bypass screens (supported by Li et al. 2015), and, while probably less likely, (2) the horizontal distribution of fish as they approach a dam will also affect their route of passage depending on whether they approach on the spillway side or the powerhouse side; however, to the best of our knowledge this distribution is likely not dependent on fish size. Additional information can be referenced in Faulkner et al. (2015).

E.5 JUVENILE FISH RESPONSE – SUMMER MIGRANTS

The dam passage survival performance testing that began in 2010 includes estimating survival for subyearling fall Chinook salmon, which typically migrate through the CRS during the late spring and early summer. The results of performance standard testing have generally been positive and estimated survival has exceeded the 93 percent BiOp survival standard for this species during at least one test conducted at each dam evaluated to date (Table E-4; Figure E-17). When the results of the recent testing are considered together, this indicates that passage improvements implemented at the eight lower CRS dams under the 2008 BiOp are reducing smolt mortality by providing safe, effective passage routes in the form of surface passage and conventional spill tailored to the unique configuration of each dam.

Test results show survival of subyearling fall Chinook ranging from 90.76 percent to 97.89 percent (Table E-4). This review corroborates NMFS' analysis in the 2014 supplemental BiOp finding that, with few exceptions, BiOp measures are performing as expected and are very close to achieving, or are already achieving, the juvenile dam passage survival objectives (Figure E-17).

Table E-4. Juvenile dam passage survival estimates, passage times, and spill passage efficiency for subyearling Chinook salmon derived from performance standard tests conducted through 2014

Dam	Year	Species	Dam Passage Survival (percent with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (percent)	Spill Operation (Target / Actual)
Bonneville ^a	2012	Subyearling Chinook Salmon	97.39 (0.69)	0.48	57.06	85 kcfs day – 121 kcfs night / 149 kcfs 95 kcfs 24 hrs / 149 kcfs
The Dalles ^{b,c}	2010	Subyearling Chinook Salmon	94.04 (0.91)	1.20	71.22	40% / 39.8%
The Dalles ^d	2012	Subyearling Chinook Salmon	94.69 (0.59)	1.08	70.74	40% / 40.4%
John Day ^e	2012	Subyearling Chinook Salmon	94.14 (0.31)	1.02	69.62	30% / 37.9% 40% / 37.9%
John Day ^f	2014	Subyearling Chinook Salmon	91.96 (0.74) 91.31 (0.77) 91.69 (0.61)	2.28 1.91 2.12	55.52 71.26 63.67	30% / 30% 40% / 40% Pooled
McNary ^{g,h}	2012	Subyearling Chinook Salmon	97.47 (1.14)	1.77	78.32	50% / 61.6%
McNary ⁱ	2014	Subyearling Chinook Salmon	92.39 (1.80)	2.22	53.80	50% / 48.8%

Dam	Year	Species	Dam Passage Survival (percent with Standard Error)	Median Forebay Passage Time (hours)	Spill Passage Efficiency (percent)	Spill Operation (Target / Actual)
Lower Monumental ^j	2012	Subyearling Chinook Salmon	97.89 (0.79)	2.60	83.56	17 kcfs / 25.2 kcfs
Lower Monumental ^k	2013	Subyearling Chinook Salmon	92.97 (1.05)	2.99	89.10	17 kcfs / 19.8 kcfs
Little Goose ^l	2012	Subyearling Chinook Salmon	95.08 (0.97)	2.80	72.49	30% / 38.5%
Little Goose ^k	2013	Subyearling Chinook Salmon	90.76 (1.39)	3.66	76.83	30% / 30%
Lower Granite ^m	2018	Subyearling Chinook Salmon	94.22 (2.17)	2.15	79.7	18 kcfs / 18 kcfs

References by dam: Bonneville ^aSkalski et al. 2013e; The Dalles ^bJohnson et al. 2011; ^{c,d}Skalski et al. 2012a; 2012c; John Day ^{e,f}Skalski et al. 2013d; 2014; McNary ^gHughes et al. 2013; ^{h,i}Skalski et al. 2012d, 2014; Lower Monumental ^{j,k}Skalski et al. 2013a, 2013c; Little Goose ^{l,k}Skalski et al. 2013b, 2013c; Lower Granite ^mSkalski et al. 2019.

Notes: There were no tests conducted in 2015, 2016 or 2017; Spill passage efficiency is the percent of all downstream migrating juvenile salmon and steelhead that pass a dam through the spillway and other surface passage routes.

Unlike the situation for spring migrants, direct estimates of survival through the CRS reach for summer migrants such as SR fall Chinook salmon are limited. This is the result of complications associated with accurately estimating survival, given the complex life history strategies of subyearling Chinook. Some members of the population exhibit protracted migrations and rear as they slowly migrate downstream. Others hold over in reservoirs and continue their migration into the fall and winter, or even the following year (Connor et al. 2005). This complex pattern has been recognized more recently, and violates one of the standard assumptions of the statistical model used to estimate survival over extended river reaches.

Performance standard testing conducted by the Corps does provide estimates of fish residence time in dam forebays. Test results indicate that subyearling Chinook salmon spend a relatively brief period searching for passage routes. The median elapsed time from first arrival at the dam to passage has ranged from about half an hour at Bonneville (Skalski et al. 2013e) to over 3.66 hours at Little Goose (Skalski et al. 2013c).

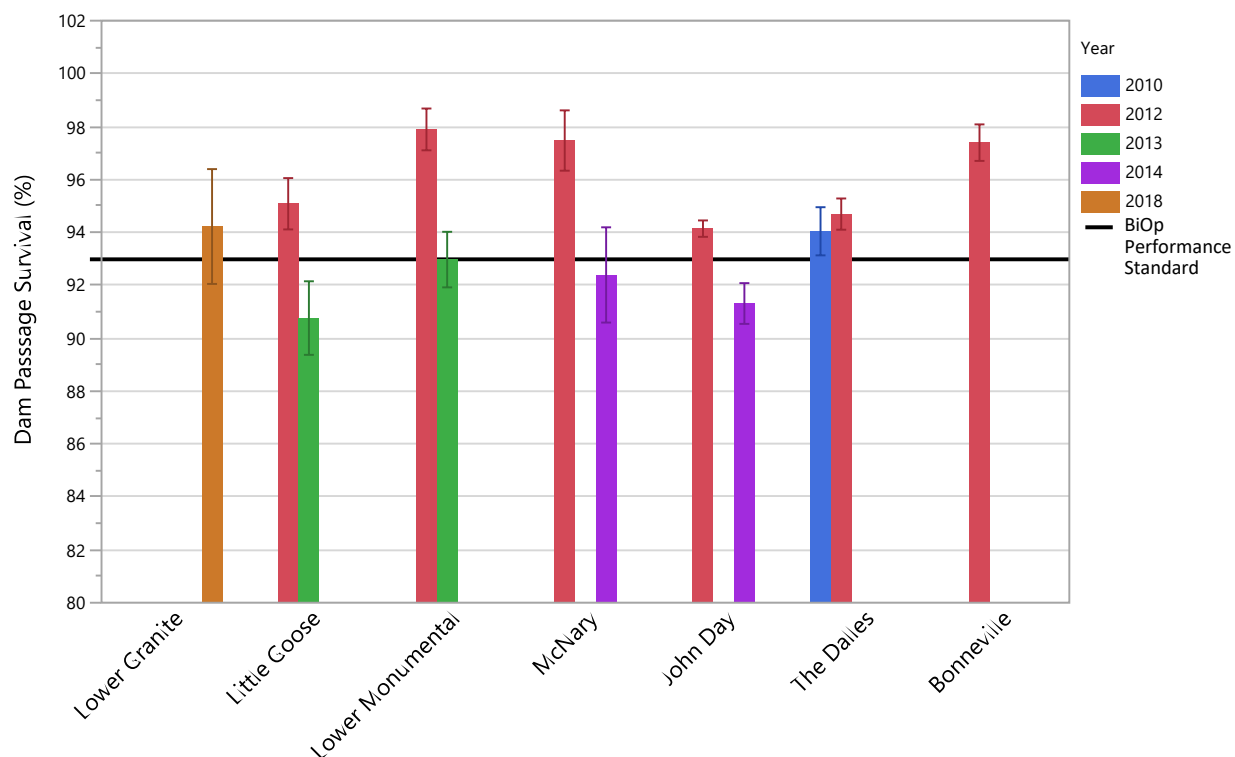


Figure E-17. Estimated dam passage survival for subyearling fall Chinook salmon. Data is based on sources in Table E-4. The 2008 BiOp spring performance standard is 93 percent for subyearling Chinook salmon. Bars represent dam passage survival. Whisker plots represent standard error.

Tuomikoski et al. (2011) compared travel times of subyearling SR fall Chinook salmon from Lower Granite to McNary Dams between two different passage eras. For the period from 2005 to 2010 mean fish travel time was 11.2 days, compared to 21.3 days for the same reach during preceding era from 1998 to 2004. They attributed the reduction in travel time to the implementation of summer spill, which began in 2005. However, system monitoring also indicates that the faster migration of juvenile fish through the CRS reflects the combined effects of flow augmentation, spill, and recently installed surface passage systems. This assessment is complicated by the apparent life history change in which some subyearling Chinook salmon cease active migration in midsummer and hold over in reservoirs. Operations designed to facilitate migration during this time may instead simply redistribute these fish within the system.

E.6 EFFECTIVENESS OF AUGUST SPILL

When developing the action described in Chapter 2, the Action Agencies extensively reviewed existing data since the 2008 BiOp related to smolt migration timing through the lower Snake and lower Columbia Rivers during the summer months, particularly in August.

The current run timing of juvenile SR fall Chinook salmon is such that relatively few wild juvenile fish are migrating downstream through the Snake and Columbia Rivers during the month of August.

Consequently, only a small percentage of the overall juvenile population encounters August spill at the lower Snake and Columbia River dams. Rearing and migratory behavior of fall Chinook, both hatchery and natural production, is relevant when evaluating the effectiveness of August spill operations to improve passage through the fish passage dams.

Fall Chinook salmon from the Snake River are believed to have historically migrated downstream during summer months as subyearlings and have generally been considered in that context until recently.

Research has found that this ESU now exhibits a variety of rearing and migratory strategies including subyearling and yearling migrants with ocean-and reservoir-type patterns, respectively (Connor et al. 2005, 2011). The reservoir-type life history strategy is a result of complex interactions between the thermal regimes fish are exposed to during incubation and rearing each year, water flow at dams and reservoirs in their migration corridor during the first one-third of summer migration (Waples et al. 2007; Connor et al. 2011), and variable hatchery practices. Juveniles that reach a minimum size threshold by early summer typically experience a photoperiod cue to hormonally initiate smoltification, while those that are too small in early summer remain in a slower growth trajectory and only experience the smolt transition the following spring (Perkins and Jager 2011). Reservoirs and lakes take more time to warm in spring than nearby streams, and also cool later in fall. Temperatures strongly influence both intrinsic growth rates and food availability for parr. Most fall Chinook with the yearling or reservoir type pattern originate from the Clearwater River, which has a cooler thermograph than many other major tributaries in the Snake River Basin. In addition, flow augmentation from Dworshak Dam has the effect of additional cooling on the lower Clearwater and Lower Granite Reservoirs. The resulting slower growth rates have delayed smoltification and migration of juvenile fall Chinook salmon (Tiffan et al. 2009).

The median date of subyearling fall Chinook passage through the Snake River is June 16 (Connor et al. 2013). Investigations indicate that fall Chinook salmon which do not actively migrate downstream beyond the month of July hold over in reservoirs or other parts of the river, feeding and growing before continuing their downstream migration later in the year or the following spring as yearlings (Tiffan et al. 2009; Zabel et al. 2012). The bulk of naturally produced fall Chinook salmon in the Clearwater River tend not to pass Lower Granite Dam until after August 31 when spill operations have concluded but when transportation via trucks is still ongoing.

The majority of subyearling fish that overwinter reside and forage in the Snake River; a small fraction of these fish have been recorded moving downstream and may overwinter in the Columbia River (Tiffan et al. 2009). Zabel et al. (2012) reported that 62 percent of returning adult fall Chinook salmon sampled at Lower Granite Dam in 2006–2008 had followed a yearling life history as juveniles and proposed that the high percentage provides circumstantial evidence of a survival advantage associated with the delayed migration.

In the 2008 BiOp, NMFS recommended spill be provided through at least July 31 at lower Snake River dams and through August 31 at Columbia River dams. At the lower Snake River dams, based on RPA Action 29 in the 2008 BiOp, summer spill can be adjusted based on the number of migrating juvenile fish observed by specifying that spill will continue at the four lower Snake River dams until daily passage counts of subyearling fall Chinook salmon fall below 300 fish for 3 consecutive days after August 1. The RPA also calls for restarting spill if fish numbers later increase above 500 fish for 2 consecutive days. This concept was further refined in the 2008 Columbia Basin Fish Accords (Accords), in which the Action

Agencies agreed that if the trigger was met, spill would end at the four dams on a staggered basis, continuing longer at dams farther downstream to support fish migrating toward the ocean. To enhance the summer spill program even further, the Action Agencies developed a safeguard based on adult returns, whereby a low abundance of returning naturally produced SR fall Chinook adults would trigger continuing spill through the end of August at lower Snake River projects the following year, regardless of the number of juveniles migrating downstream that year. Although these criteria to adjust summer spill timing remain in place, the Action Agencies have continued to spill through August each year regardless of daily juvenile fish counts. Thus, this aspect of RPA Action 29 has never been implemented, nor has the site-specific staggered spill curtailment called for in the Accords occurred.

As discussed above, based on observed subyearling Chinook salmon collection counts at each lower Snake River dam since 2005, the timing of the SR fall Chinook salmon downstream migration is such that relatively few fish migrate past Snake and Columbia River dams during the month of August. Lower Granite Dam, the uppermost project, is included as an example (Figure E-18) and illustrates the annual variability in passage. Since 2010, the proportion of the annual outmigration passing the three uppermost Snake River dams during August ranged from 0.23 to 6.59 percent (Table E-5). If spill had ended when fish numbers declined as described in the 2008 BiOp and Accords guidelines, the ending date would have varied each year but could have occurred as early as August 1. Analysis shows that an average of 0.3 to 1.8 percent of all migrating fall Chinook migrate past the Snake River dams after August 31 depending on location (Table E-5).

The data indicate that if the 2008 BiOp provisions for implementing summer spill based on actual migration timing of the fish rather than calendar dates had been implemented, spill would have been provided for at least 97 percent of all juvenile SR fall Chinook salmon since 2005. Conversely, extending spill at Snake River dams through the month of August during this period has provided spillway passage for up to an additional 3 percent of this listed species during most years, depending on dam and year.

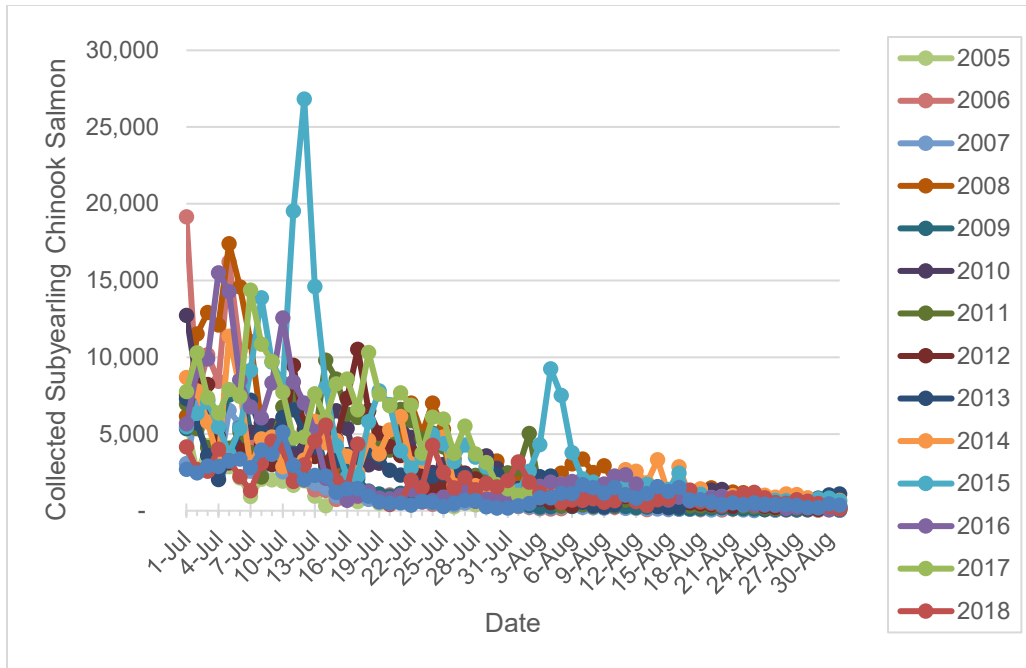


Figure E-18. Annual collection counts of all subyearling Chinook at Lower Granite, 2005–2019. Source: DART.

Table E-5. Proportion of summer migrants passing Snake River dams, 2010–2019

Year	Project	Percent of total run passed in August	Percent passed by Aug 31 ^a
2010	Lower Granite	1.98%	98.09%
	Little Goose	2.44%	99.52%
	Lower Monumental	1.11%	99.92%
2011	Lower Granite	1.77%	98.31%
	Little Goose	2.06%	99.46%
	Lower Monumental	4.90%	98.86%
2012	Lower Granite	1.65%	98.31%
	Little Goose	2.11%	99.58%
	Lower Monumental	1.45%	99.39%
2013	Lower Granite	3.56%	94.75%
	Little Goose	5.06%	96.85%
	Lower Monumental	4.76%	99.54%

Year	Project	Percent of total run passed in August	Percent passed by Aug 31 ^a
2014	Lower Granite	4.26%	98.44%
	Little Goose	5.03%	99.73%
	Lower Monumental	2.60%	99.69%
2015	Lower Granite	4.89%	99.22%
	Little Goose	1.17%	99.68%
	Lower Monumental	0.52%	99.90%
2016	Lower Granite	2.53%	98.42%
	Little Goose	1.58%	98.96%
	Lower Monumental	0.32%	99.85%
2017	Lower Granite	-	-
	Little Goose	1.07%	99.43%
	Lower Monumental	0.23%	99.96%
2018	Lower Granite	2.93%	99.08%
	Little Goose	1.10%	99.81%
	Lower Monumental	0.46%	99.92%
2019	Lower Granite	3.57%	99.05%
	Little Goose	6.59%	99.33%
	Lower Monumental	0.67%	99.77%
Ave	Lower Granite	3.02%	98.19%
	Little Goose	2.82%	99.24%
	Lower Monumental	1.70%	99.68%

^a RPA No. 29 has summer spill planning dates through August 31 at the four lower Snake projects. Spill dates may be adjusted (increased or decreased) for research purposes or through the adaptive management process (to better match juvenile outmigration timing, and/or to achieve or maintain performance standards).

Smolt monitoring counts and downstream PIT detections were examined (2010–2019) to consider the differences in run timing of natural versus hatchery-produced subyearling fall Chinook salmon in the lower Snake River (Figure E-19). Three periods of increased passage of natural production fish from the Clearwater were observed at Lower Granite and Little Goose Dams for all run types: these periods of increased passage occurred in April, July, and again in October-November (Figure E-20). At Lower

Granite Dam, the first peak of natural production origin were all fish migrating as yearlings (holdover), while the second and third peaks were comprised of only subyearling fish.⁸

During the month of August, an average 3 percent of naturally produced subyearling fall Chinook salmon pass downstream of Lower Granite and Little Goose Dams, most of which occurs during the first weeks of August when surface water temperatures reach 18–20°C. At Lower Monumental Dam, on average less than 2 percent of the subyearling fall Chinook salmon pass downstream in the month of August - most fish have passed by August 6.

When developing the Proposed Action for the 2019 BiOp, the Action Agencies reviewed the data above and contemplated alternate scenarios for providing August spill at the Snake River fish passage dams versus transporting those remaining juvenile fish that may still be moving between reservoirs on the Snake River. The 300 fish collection count threshold that had been developed by biologists from the Action Agencies, Lower River Tribes, and NMFS for the 2008 BiOp was reviewed and determined to still be an appropriate indicator that the vast majority of the ESU has migrated past the projects. Before selecting the trigger detailed in Chapter 2, the Action Agencies carefully considered different numbers of consecutive days of collection counts below 300 fish, whether the decision to provide spill at each project should be dependent on the project upstream, and whether to include a collection count threshold above which spill would be restarted after it had stopped. The Action Agencies were also mindful of alternate methods of passage that are provided during the month of August as well as later into the fall. As discussed further in the Section D.7., it appears that beginning in August and continuing through the fall, Chinook salmon that are collected at the Snake River dams and transported to rear and potentially holdover in the estuary below Bonneville Dam return as adults at higher rates than those that were returned to the river to migrate instream.

In the lower Columbia River, the run timing of juvenile fall Chinook salmon is composed of two ESUs: the ESA-listed SR fall Chinook and non-listed middle Columbia River (MCR) fall Chinook, which migrate primarily out of the Hanford Reach of the Columbia River. The run-timing index of the combined runs (via the smolt monitoring program) depicts that 95 percent of the subyearling fall Chinook run has passed John Day Dam and Bonneville Dam by August 1 with few exceptions (2011 and 2012, both years experienced late run-timing). At McNary Dam, smolt monitoring counts and PIT detections over the past decade were more variable (Figure E-21). Analysis of PIT detections at all three aforementioned dams found that SR and CR juvenile fall Chinook in 2010-2019 typically complete the majority of their downstream migration by August 1 (Tables E-5 and E-6).

⁸ The analysis of PIT tag detection at Lower Granite Dam juvenile bypass system is assumed to be representative of the run at large; however, relatively few natural origin fish from the Clearwater subbasin are PIT tagged as subyearlings.

Number of Hatchery Origin PIT Detections at Juvenile Bypass Systems

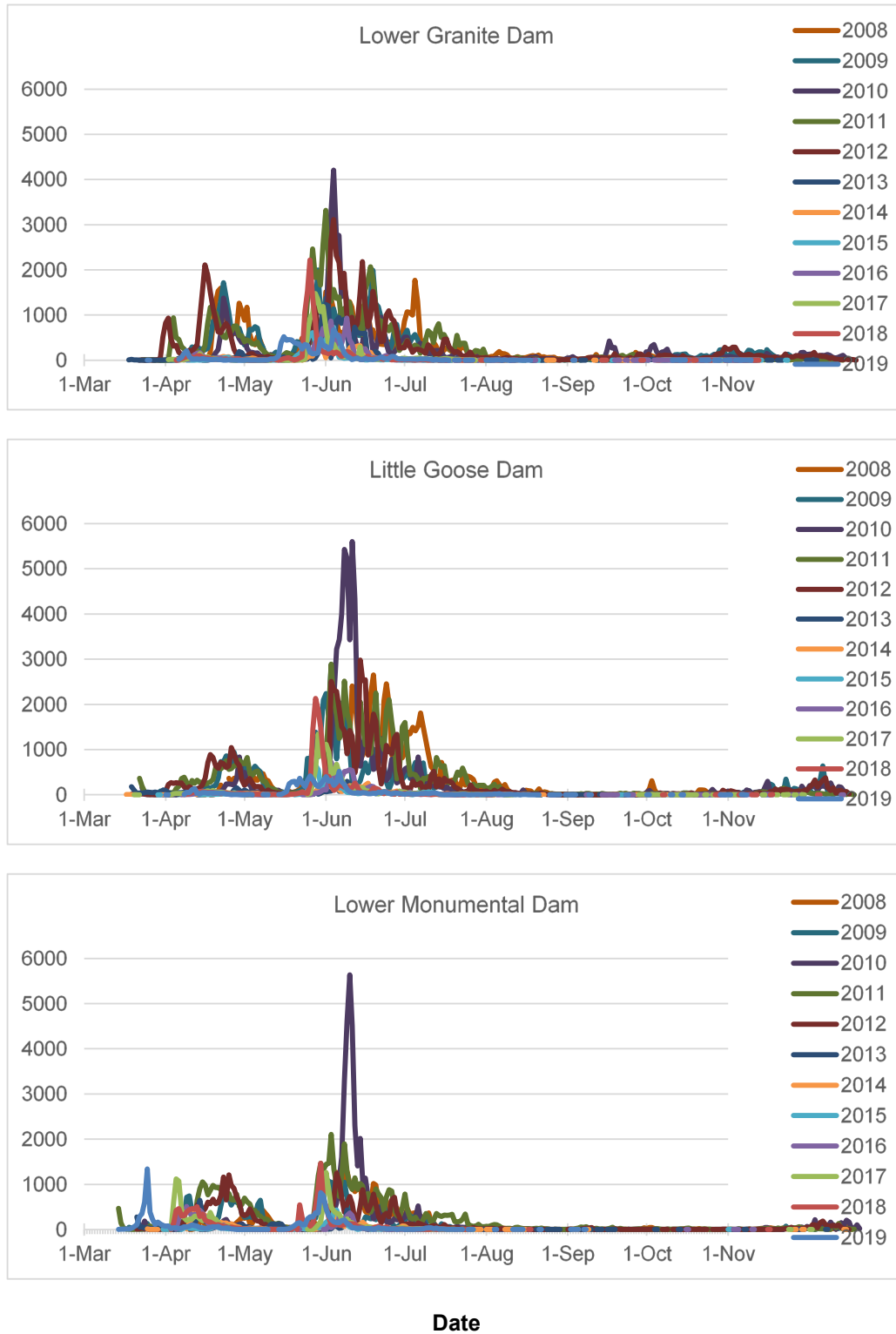


Figure E-19. Distribution of hatchery-origin PIT-tagged subyearling SR fall Chinook salmon detected in the juvenile bypass systems at Lower Granite, Little Goose, and Lower Monumental Dams over the past 10 years. Source: DART.

Number of Natural (Wild) Origin PIT Detections at Juvenile Bypass Systems

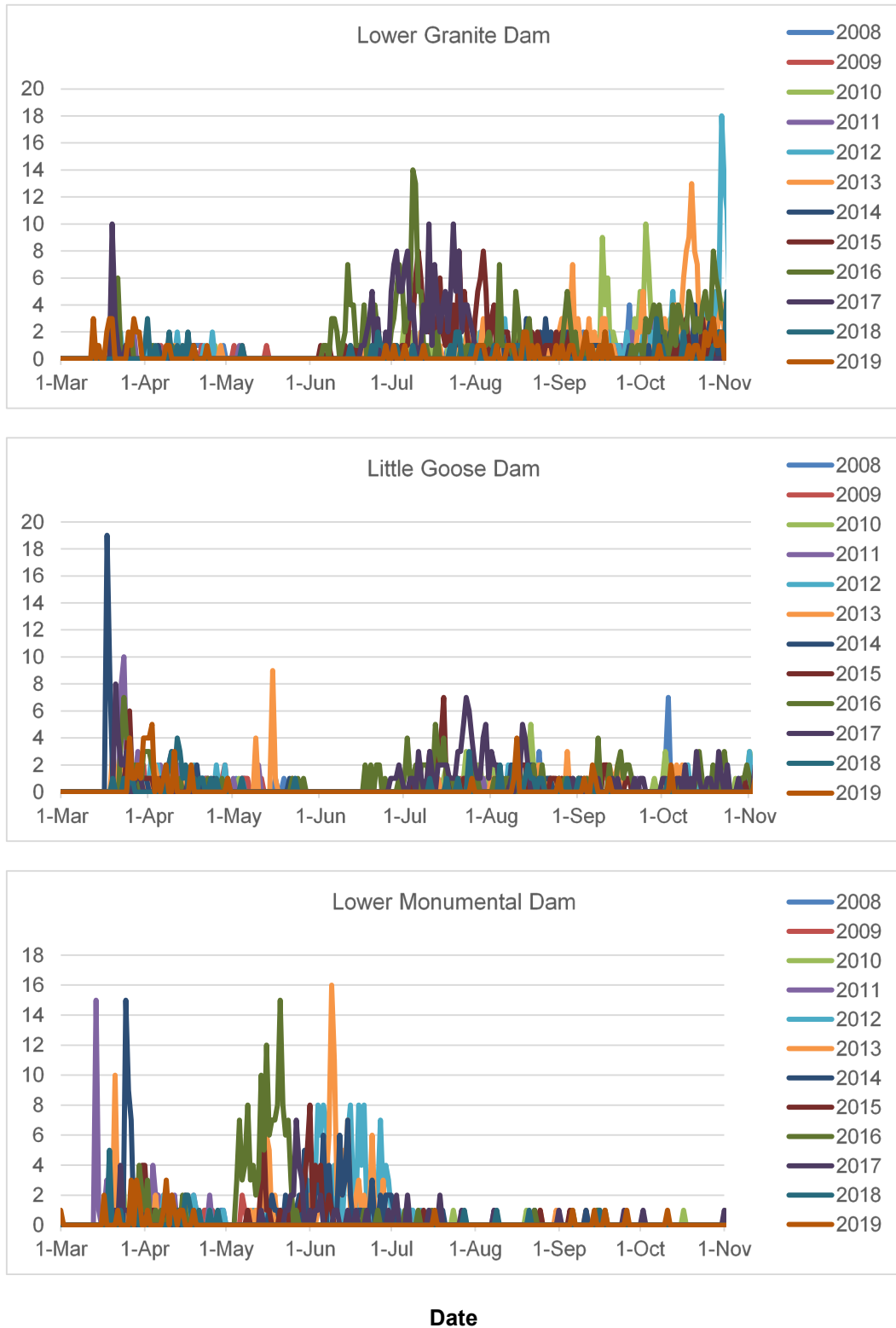


Figure E-20. Distribution of natural-origin (Clearwater, wild) PIT-tagged subyearling SR fall Chinook salmon detected in the juvenile bypass systems at Lower Granite, Little Goose, and Lower Monumental Dams over the past 10 years. Source: DART.

Additional monitoring and analysis may be necessary to determine the source of variability of subyearling fall Chinook passage timing at McNary Dam, more specifically, whether the detections of PIT-tagged fish at McNary Dam in August represent actively migrating fall Chinook or whether some portion of those fish represent reservoir-type behavior of smaller migrants that will migrate to the ocean during the winter months or as yearlings the following spring. Additional analysis may also be necessary of the total number of PIT-tagged fish that are migrating through the lower Columbia River in August and whether the distribution and sample size are adequate to make conclusions about the run at large.

In the 2008 BiOp, NMFS recommended August spill operations at the lower Columbia River dams continue through August 31 without reference to fish presence, unlike at the lower Snake River dams, where NMFS recommended the summer fish passage spill season duration be tailored to run timing using a biological trigger. Additional investigations may be required to improve our understanding of the movement characteristics of CR and MCR fall Chinook salmon through the lower Columbia River projects, the temporal overlap between the two ESUs, any run-timing shifts to earlier migration, and the potential effect of any modifications to spill during the month of August on ESA-listed SR Fall Chinook.

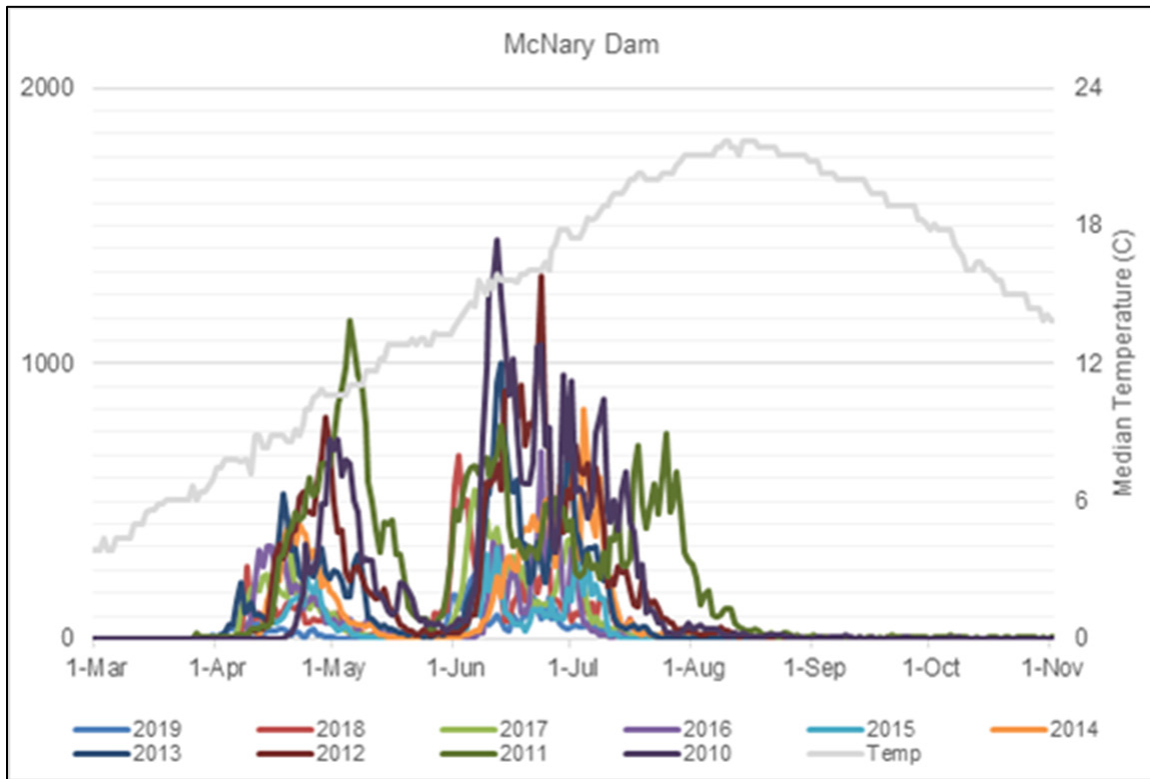


Figure E-21. Distribution of PIT-tagged subyearling fall Chinook salmon detected at juvenile bypass systems at McNary (top figure) and Bonneville (bottom figure) dams (2010–2019)

Table E-6. Number of PIT-tagged subyearling fall Chinook salmon detected in the estuary and also detected at Juvenile Bypass Systems (JBS) at Bonneville, John Day Dam, and McNary Dam by origin and rear type, 2010–2019. (JBS detection efficiency shown in parentheses).

Origin	Rear type	Estuary Detections	Juvenile Bypass Detections		
			Bonneville ^a	John Day	McNary
Columbia River	Hatchery	2,022	257 (12.7%)	229 (11.3%)	227 (11.2%)
	Wild	243	22 (9.1%)	12 (4.9%)	30 (12.3%)
Snake River	Hatchery	9,578	793 (8.3%)	1,049 (11.0%)	1,187 (12.4%)
	Wild	22	-	4 (18.2%)	5 (22.7%)
All		11,865	1,072 (9.0%)	1,294 (10.9%)	1,449 (12.2%)

^a Juvenile detections at Bonneville Dam include the Bonneville PH2 Juvenile (B2J) and Bonneville PH2 Corner Collector (BCC) interrogation sites.

E.7 JUVENILE TRANSPORTATION

The transportation program has been operational in the lower Snake River for more than three decades. It involves diverting migrating smolts from turbine intakes at collector dams (Lower Granite, Little Goose, and Lower Monumental) and transporting the fish, primarily by barge, to release sites downstream from Bonneville Dam. The collection systems can also be operated in a bypass mode when transport is not warranted, returning fish directly to the river to continue their migration.

Juvenile fish are transported in accordance with the annual Fish Passage Plan. Protocols and criteria for collection, holding, and transport of juvenile fish are further defined in the Juvenile Fish Transportation Plan, included as Appendix B of the annual Fish Passage Plan, available online at:

<http://pweb.crohms.org/tmt/documents/fpp/>. Implementation of the Juvenile Fish Transportation Plan, including deviation from the plan and criteria described in Appendix B of the Fish Passage Plan, is coordinated through the Regional Forum.

In the Snake River, there are two general passage options for smolts: (1) collection and transport from dams fitted with screened collection/bypass systems, or (2) in-river migration to the ocean via some combination of routes including conventional spillways, surface passage, screened bypasses or turbines. With full implementation of surface passage routes at all eight dams on the lower Columbia and lower Snake Rivers coupled with spill for juvenile fish passage at each dam, the majority of juvenile fish migrate in-river.

The goal of the transportation program is to increase the proportion of fish that return as adults to spawn. The objective of the program is to improve smolt survival by avoiding the potential challenges associated with passing multiple CRS projects. Research has also indicated potential benefits associated with arrival of fish in the lower Columbia River and estuary when increased productivity makes more food resources available (Scheuerell et al. 2009).

RIOG and TMT review transport studies and provide a recommendation each year to the Corps on how to operate the juvenile transport program. The transportation of juvenile fish at Lower Granite, Little

Goose, and Lower Monumental Dams will have a proposed transport start target date of April 24, but may begin as early as April 15 and no later than May 1, or as coordinated through the Regional Forum process.

The timing and conditions for transport are empirically based, relying on data indicating that adult return rates are higher for juveniles that are transported at certain times than for their counterparts that migrate in-river through the CRS. For example, results have shown that transportation in early April is generally not beneficial to Chinook salmon, while transportation in early May has shown consistent improvement compared with in-river migration for both Chinook and steelhead. The result is that transportation in early April has been curtailed in recent years. Additionally, recent results reported by Smith (2017) indicate that more wild Chinook adults transported as juveniles from Lower Granite return from all years between 2006 and 2014, except for 2011. For wild steelhead at the same dam, more transported adults returned for every year in that period. These findings appear to support the benefits of targeted implementation of transportation.

Key metrics used in these comparisons include SAR for each treatment group, along with various ratios derived from the SAR estimates, generally referred to as the transport to in-river migrant ratio (TIR). This ratio and its variants, described in Smith et al. (2013), are used to assess the effectiveness of transporting smolts:

1. $TIR > 1.0$ indicates that transported fish survive to returning adult at rates exceeding in-river migrants (i.e., the SAR for transported fish was higher than for in-river fish).
2. $TIR < 1.0$ indicates that in-river fish survive to returning adult at higher rates than those transported (the SAR for transported fish was lower than for in-river fish).

E.7.1 Spring migrants

Spring–summer Chinook salmon, steelhead, and sockeye migrate through the Snake River during the spring migration period, primarily April through early June. Their migration timing overlaps at varying degrees each year. Thus, the decision to transport, or not, affects all species present. These issues are discussed in the following sections by examining broad scale, species-specific annual responses to transport, as well as within-year variation in responses.

E.7.1.1 Transportation evaluations

SPRING CHINOOK AND STEELHEAD

Two analytical groups regularly evaluate the effectiveness of transportation: the Fish Passage Center, which coordinates the CSS, and the Science Center.

Analyses of annual performance indices for more than a decade conducted by NMFS supporting the 2010 BiOp (2010 supplement to the 2008 BiOp) indicate that depending on the baseline used, transported wild spring Chinook salmon survived at about the same, or slightly higher rates than in-river migrants. Hatchery-origin yearling Chinook salmon exhibited even more significant transport-to-migrant (T:M) ratios that were typically greater than 1.0, regardless of the baseline examined. (The T:M ratio is a variant of TIR, discussed earlier.) Similarly, for the decade ending in 2009, both wild-and hatchery-origin

steelhead that were transported survived to return as adults at higher rates than cohorts migrating in river (NMFS 2010), as evidenced by the TIR estimates well above 1.0.

Separately, Holsman et al. (2012) analyzed PIT-tag data from 1998–2006 and found that considering the marine component of the life cycle yielded very different results among rearing histories that were not apparent in the T:M ratio. The survival of transported wild Chinook salmon in the marine environment was about two-thirds less than that of counterparts migrating in-river. In contrast, transported hatchery Chinook survived their marine residence at approximately twice the rate of in-river migrants. The two studies, conducted by NMFS investigators, characterize wild Chinook responses to transportation somewhat differently, ranging from negative to slightly positive. This apparent discrepancy may depend in part on the different time frames (years) included in the separate analyses.

Unintended consequences of barging smolts are also of concern. Recently, the effect of barging on adult straying rates has received increased attention (Keefer and Caudill 2012). It remains unclear whether increased stray rates associated with transportation have been excessive.

Despite the results of these transportation studies to date, the most relevant and applicable information on the effects of transportation on survival is from the most recent years after the 2008 BiOp, when all of the dams in the CRS have been outfitted with surface passage routes and additional spill has been integrated into CRS operations. Those actions appear to have substantially improved passage conditions for in-river migrants. Therefore, the most accurate comparison with transportation to current in-river survival experiences should be based on adult returns beginning in the 2009 juvenile out migration.

For more than a decade, the Action Agencies, NMFS, and regional forums (e.g., AFEP, FPOM, TMT) have explored ways to balance transportation and in-river migration to increase the abundance and productivity for listed ESUs and minimize the risk of unforeseen negative conditions/effects during the juvenile migration in any particular year, given the vagaries of environmental conditions (temperature, flows, etc.). This balance is often referred to a “spread-the-risk” operation. It involves distributing the population between transportation and in-river migration, by tailoring operations between conventional sub-surface spill, surface passage routes and screened bypass systems.

A spread-the-risk operation presumes an approximate balance between the fish left to migrate in the river and those that are collected and transported. However, with the successful implementation of surface passage routes and the changes in spill operations under the 2008 BiOp, the majority of fish now pass through CRS projects via spillways and a decreasing number are available for collection in juvenile bypass systems. This has translated into fewer yearling spring Chinook salmon and steelhead transported from the Snake River each year (Figure E-22). Long-term data trends are evident, with an inflection point in 2006 clearly demonstrating when surface passage and spill effects on transport percentages became evident.

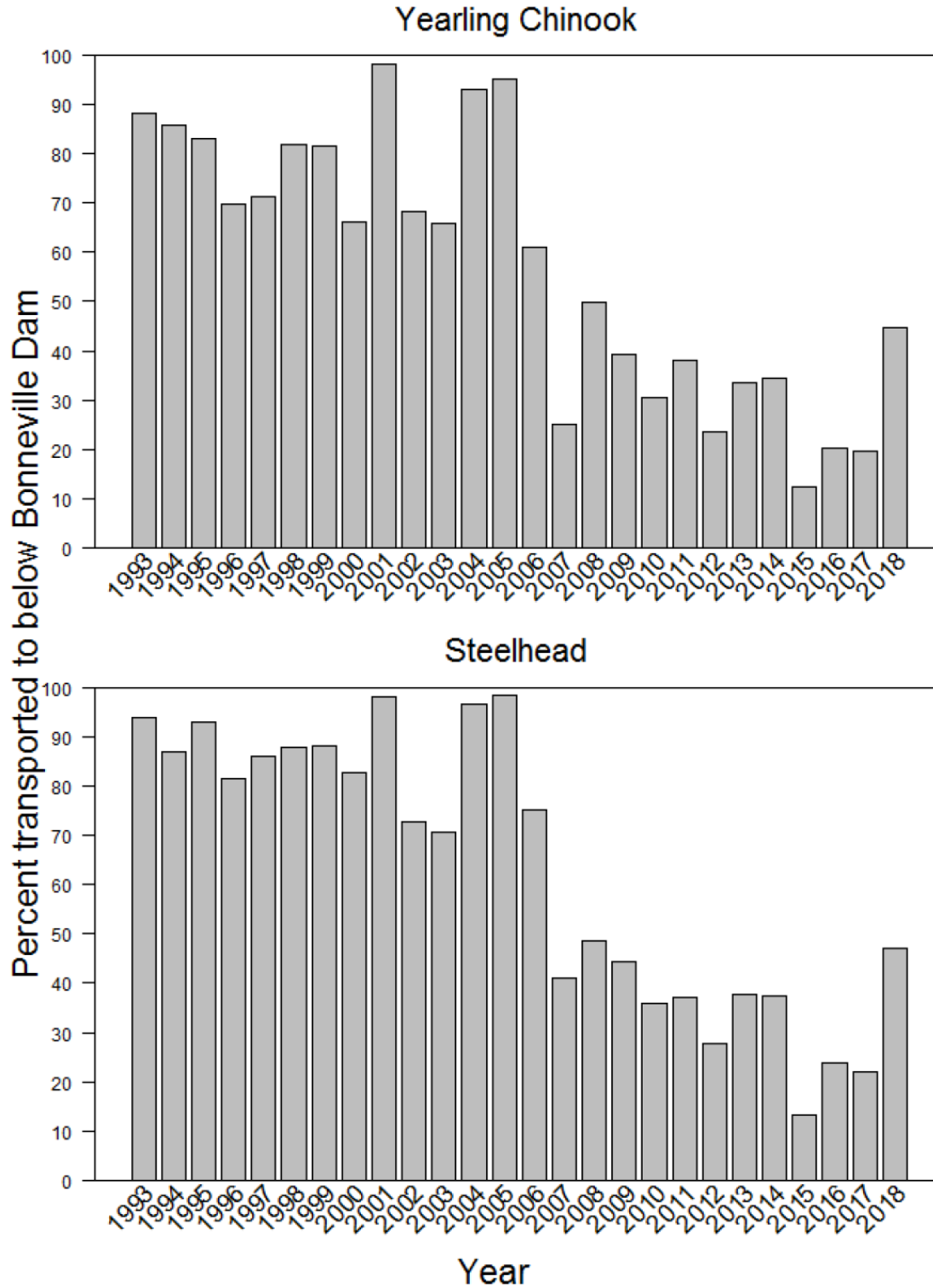


Figure E-22. Estimated percent of yearling Chinook salmon and steelhead, respectively, transported to below Bonneville Dam, by year, 1993–2018. (Figure from Widener et al. 2019).

SR SOCKEYE SALMON

For SR sockeye salmon, there are less data available to evaluate transportation effects. A study has been initiated to examine the relative survival of sockeye experiencing either transport or in-river migration conditions. For that study, sockeye salmon smolts were PIT tagged at Sawtooth Hatchery in Idaho and Oxbow Hatchery in Oregon. Results from 2009 suggest that transport is neutral for Sawtooth Hatchery-reared sockeye, but beneficial for Oxbow Hatchery-reared sockeye, which were larger than Sawtooth Hatchery fish (Biomark and Quantitative 2012). However, fish from each hatchery were also released at different sites, which could have influenced these results. Importantly, data from a single year are inadequate to provide a definitive evaluation of transportation for this species.

In its annual update on transportation effects, NMFS reported on transport effects on SR sockeye salmon between 2011 and 2016 (Smith 2017). Based on that data, it appears that sockeye salmon transported as juveniles from Lower Granite tend to return as adults to Bonneville Dam in greater numbers than their counterparts that were bypassed back to the river during their juvenile outmigration. However, once the adult sockeye from both groups make it back to Bonneville Dam, the transported group can have much lower migration success compared to the in-river bypassed group. Transported adults have increased stray rates and slower migration upstream, which increases their exposure to warmer river temperatures and potentially harvest. Data analysis from the CSS also shows that TIR ratios from Lower Granite to Lower Granite tend to be less than 1 (negative impact).

E.7.1.2 Intra-annual variation in survival and SAR

Broad annual indices of transportation effects do not fully inform decisions facing fishery and CRS managers. This is because within-year variation in survival makes the situation more complicated. Management decisions involve identifying when within a year, and at which sites, transportation provides benefits. The decisions are complicated by the presence of three different salmon and steelhead species during the spring migration period, each of which seem to respond differently to transportation. Recent analyses by NMFS provide information useful for exploring these issues.

Annual analysis by NMFS (Smith 2017) examined seasonal (intra-annual) patterns in SAR for various classes of transported and in-river migrating SR steelhead and spring-summer Chinook salmon. The NMFS results for 2006 to 2014 suggest that postponing transport until late April or the first week of May should improve survival for wild Chinook, hatchery steelhead and perhaps hatchery Chinook salmon. Findings by Holsman et al. (2012) support the decision to delay the onset of transportation until later in the spring migration, at least as a benefit for wild Chinook salmon. Recent adaptive management decisions to begin transport on May 1 reflect these findings. But the outcome is less certain for wild steelhead, which generally have improved survival when transported at any time during the spring migration.

With respect to transporting smolts after the first week in May, the data discussed above clearly show that in the majority of years included in the NMFS analyses, yearling Chinook salmon and steelhead that were transported from Lower Granite Dam had a SAR equal to or higher than their counterparts migrating in the river. In many cases, the difference was statistically significant. This was true regardless of rear type (e.g., hatchery or natural production). In the NMFS expanded dataset, SARs for smolts outmigrating in 2012 showed a weak (not statistically significant) negative impact from transporting wild

SR Chinook salmon after the first week of May. SARs for 2014 outmigrants data also showed a shift from benefit to slight (not statistically significant) negative impact beginning in mid-May. Steelhead have always shown a positive but non-significant benefit from transporting wild SR steelhead after May 1.

The current practice of postponing transport until the first week of May appears to be advantageous to some, but not necessarily all SR ESUs. Responses vary by species and natal origin (wild or hatchery). This suggests that inter-species trade-offs between Chinook salmon and steelhead may be in play during April. In an effort to spread the risk between the alternatives of transport and in-river passage, juvenile transport has been implemented during the last week of April in the years 2018 and 2019. This will allow managers to obtain information on the potential effects of transporting juveniles earlier than May 1. Managers may need to consider which ESUs are in most need of protection, given the current status of the ESU or sub-populations, and their migration timing through the system.

E.7.2 Summer migrants (early and late fall Chinook)

Subyearling fall Chinook salmon from the Snake River are regularly transported. As part of a multi-agency investigation of relative benefits of transportation, experimental groups of hatchery and surrogate wild fall Chinook were released between 2006–2012 (Smith et al. 2017). Complete adult returns demonstrated strong seasonal patterns in relative rates of return for transported and in-river groups. Averaged across years, prior to June 15, bypassed fish that were returned to the river had a higher SAR than transported fish, while transported smolts had higher rates of return after this date, especially in August and September (Smith et al. 2017). NMFS recommended that the best day for starting transportation for subyearling Chinook would be on or near July 1. A similar seasonal contrast in relative benefit of transportation is seen among yearling Chinook and steelhead from early to late spring. This finding supports the hypothesis that early season transport of juveniles that have not completed the physiological transition into smolts may result in poor survival through the lower Columbia estuary (Gosselin et al. 2018). Currently, both annual and long-term fall Chinook studies are ongoing by NMFS, USGS, and CSS based on returning adult salmon that were tagged as juveniles.

The pattern of seasonal run timing is important for evaluating benefits of transportation to the SR fall Chinook ESU as a whole. Hatchery fall Chinook typically migrate out rapidly after release, between late May and July, while wild subyearling Chinook migrate over a longer period between May and September. The results presented by NMFS and the CSS appear to indicate that transportation neither significantly benefits nor has significant negative impacts on the SR fall Chinook ESU as a whole. Late migrating fall Chinook, which are disproportionately wild origin, benefit the most from transportation; however, the percentage of the ESU migrating after mid-July is relatively small.

The complex life history of fall Chinook salmon has complicated investigations in previous decades. Patterns of in-river survival and SAR among the cohorts of hatchery and wild surrogate juveniles released in the NMFS study demonstrated that there are trade-offs in life stage survival rates among smolts which adopt the 'ocean type' pattern of outmigration as subyearlings versus those that rear in the reservoir environment for an additional year before migrating as yearlings. Juveniles released after the middle of June, particularly the wild surrogate group, had a greater tendency to rear in the reservoirs and migrate as yearlings. In-river survival for this late release group, which had a mixture of subyearling and yearling migrants, was lower measured from the day of release than for earlier cohorts which primarily migrated as subyearlings. However, adult return rates among this late release group

that adopted the reservoir rearing strategy were often equal or higher than among the groups adopting the ocean type pattern (Smith et al. 2017).

E.8 ADULT FISH

Many of the 2008 BiOp actions have also been directed at improving migration conditions for returning adult fish, which are especially valuable to the listed species because they have survived difficult years at sea and are nearly at the point of spawning and giving rise to successive generations. The 2008 BiOp specifies performance standards for adult survival for most species and includes provisions for annually monitoring survival through the CRS. This standard is equivalent to a juvenile reach survival standard and reflects combined impacts from a number of factors that affect adult survival through the freshwater migratory corridor that are beyond the Action Agencies’ ability to manage or control.

Adult passage survival was consistently high through the mid-2000s and remains so for several species. However, adult passage survival unexpectedly declined for a period in certain Snake River species. More recent results in 2015 for SR spring/summer Chinook salmon and SR steelhead met the adult performance standards, but their 5-year averages were below the standards because of lower survival in earlier years (Figure E-23). In 2015, both the 5-year rolling averages (2011–2015) and 2015 specific results for SR fall Chinook, UCR spring Chinook and UCR steelhead surpassed the BiOp performance standard. Improvements in PIT tag monitoring capabilities may help identify the location and potential causes of any downturns in adult survival, which could include high flows and spill leading to increased adult fallback, straying, and effects of harvest.

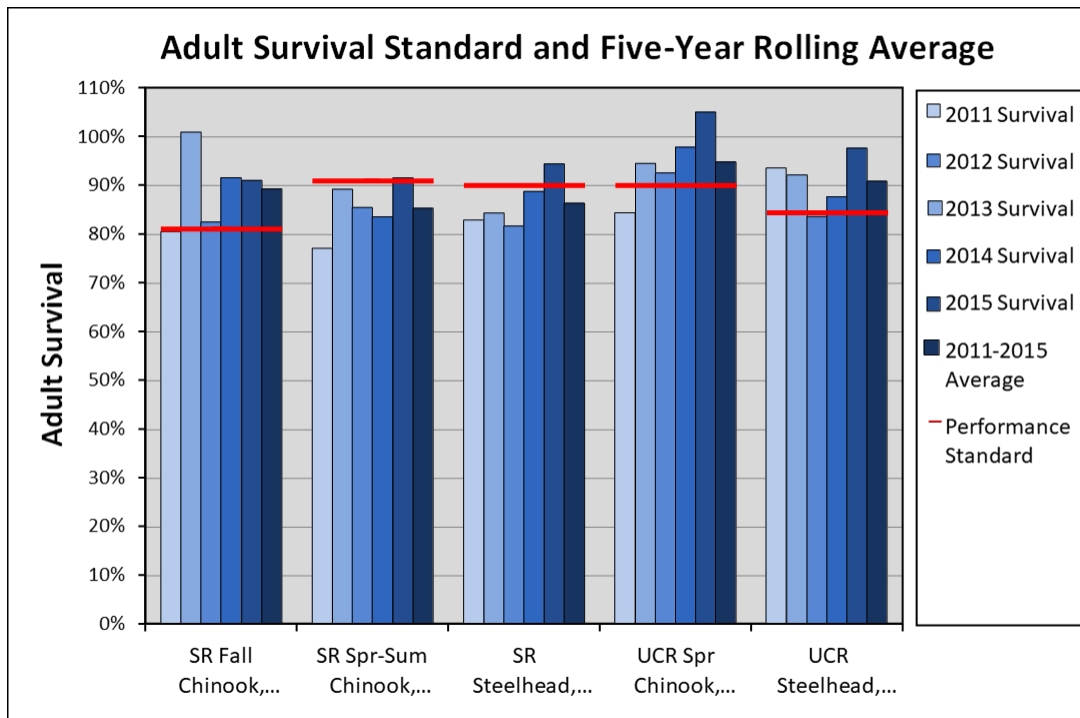


Figure E-23. Adult survival standard and five-year rolling average survival of adults that migrated in-river as juveniles, based on PIT tag conversion rates of Snake River and upper Columbia River ESUs. (BON = Bonneville, MCN = McNary, LGR = Lower Granite). Data from NMFS (Bellerud 2016).

Columbia Basin salmon and steelhead migrating upstream during the spring face a serious threat from seals and sea lions that prey on fish from the mouth of the river up to Bonneville Dam. Adult fallback at Bonneville Dam also increases exposure to marine mammal predation, and evidence suggests spring Chinook fallback may increase in correlation with higher spring spill levels. Each year since 2002, pinnipeds have consumed thousands of migrating fish (ODFW 2017), many from threatened and endangered runs protected under the ESA.

Once past Bonneville Dam, the ability of adult fish to reach their natal streams is influenced by many factors, including their successful migration through additional CRS dams via fish ladders. The 2008 BiOp identified performance standards for adult passage through selected CRS reaches (Figure E-23). These data are based on known-source, PIT-tagged adults detected at Bonneville Dam and subsequently detected (or not) at McNary Dam and Lower Granite Dam. NMFS calculates the annual point estimates and rolling five-year averages for each ESU and applicable river reach. NMFS adjusts the rates of conversion between dams for estimated harvest and straying. New ladder PIT detectors were installed at The Dalles Dam in 2013 and at John Day Dam in 2016 to provide improved spatial resolution of adult survival in the CRS and further inform analysis of adult survival.

An adult performance standard specifically for SR sockeye salmon has not been developed. However, the 2008 BiOp considered that sockeye survival is adequate if the survival standards for SR spring-summer Chinook salmon and steelhead from Bonneville Dam to Lower Granite Dam are being met. Based on the NMFS data reported above, this has not been the case except for 2015. NMFS estimated that survival of sockeye salmon through the reach ranged from 80.6 to 100.9 percent the past 5 years.

An average of 50 sockeye salmon were counted at Lower Granite Dam from 2004 to 2007. The years 2008–2011 saw improved counts of 907, 1,219, 2,406, and 1,502 fish, respectively, at Lower Granite Dam (Figure E-24). These were the largest sockeye counts since fish counting began at Lower Granite Dam in 1975. Counts were lower in 2012 and 2013, increasing again in 2014 and declining in 2015; the most recent 10-year average was 1,072 adult fish and the most recent 4-year average return was 1,107 fish.

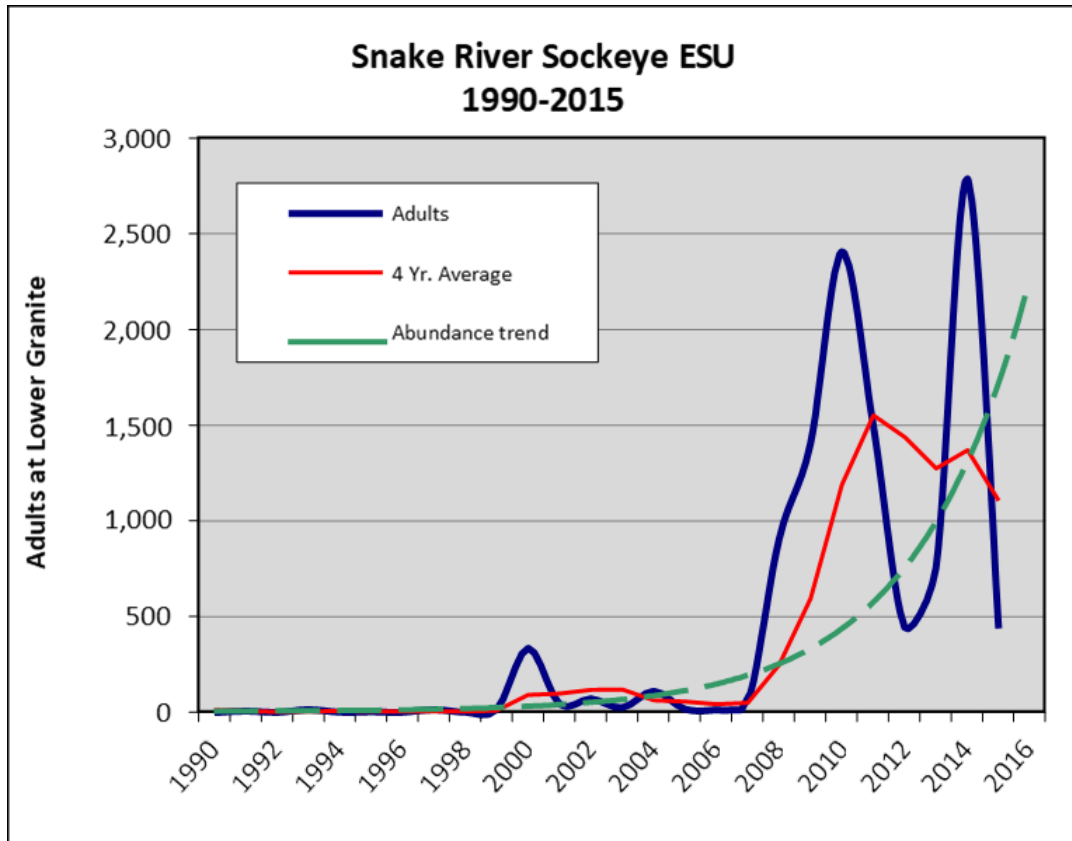


Figure E-24. Returns of all SR sockeye salmon at Lower Granite Dam, 1990–2016. The ESU-level trend in abundance was positive during this period.

In 2015, an estimated 4,069 SR sockeye passed Bonneville Dam. A low snowpack and record-setting air temperatures in June and July throughout the Columbia River Basin created water temperatures in the lower Columbia and lower Snake Rivers well above the range sockeye normally migrate through. This resulted in high mortality levels; only 1,052 adult sockeye were counted at Ice Harbor Dam, and 440 were counted at Lower Granite Dam. There was no quantifiable variation in return migration timing to Bonneville Dam in 2015 between the *adult* sockeye that had been transported as juveniles compared to those that migrated in-river as juveniles. However, the data suggest that adults that were transported as juveniles may have an impaired homing ability, which—as evidenced in 2015—delayed their upstream progress and increased their exposure to elevated mainstem temperatures (NMFS 2016). See Appendix D.7 for more discussion of juvenile salmon transportation.

E.8.1 BiOp actions for adult passage

At Little Goose Dam, it appears that installation and operation of a spillway weir that aids downstream passage of juveniles can, under certain spill conditions, hinder the upstream passage of adults.

Beginning in 2011 a new spill pattern was implemented to reduce adult passage delay, which the Corps continued to use through 2017. Problems with adult passage delay have occurred periodically. The exact conditions that cause delay are not fully understood, but it appears that spill levels greater than 30 percent during the day can contribute to the problem. Even with the modified spill patterns noted

above, passage delay was noted in 2017 during a period of high flow and high spill. The delay problem appeared to be alleviated when daytime spill levels were temporarily reduced by holding additional water behind the dam rather than spilling it. The Corps also continued design of a new adjustable spillway weir to allow rapid closure of the weir and provide more flexibility in meeting passage goals for adult and juvenile fish. Also at Little Goose Dam, warm river surface temperatures in the forebay during late summer can create a temperature difference between the adult ladder exit and the entrance, causing delays in adult passage. The Corps installed permanent pumps at Little Goose and have been operational since 2018.

At Lower Granite Dam, as at Little Goose, warm river surface temperatures in the forebay during late summer can create a temperature difference between the adult ladder exit and the entrance, causing delays in adult passage. Modifications to the juvenile bypass system route excess water to the adult trap. In addition, the Corps installed two “intake chimneys” at Lower Granite Dam, drawing pumped water from 66–70 ft deep in the forebay. One chimney releases supplemental cool water to the fish ladder at Diffuser 14 about 150 ft downstream from the top of the ladder and to the fish trap. The second chimney sprays cooler water at the upstream exit of the ladder in order to moderate the temperature differential as adults exit into the forebay (Corps 2016). These improvements were completed and installed during the winter of 2015-2016 and successfully tested during the 2016 fish passage season. Water temperature measurements conducted during the study indicated that the temperature control structure (TCS) effectively reduced near-surface water temperatures, near the ladder exit (Anchor QEA 2017).

These improvements notwithstanding, the survival for some Snake River species warrants continued investigation. Unfortunately, while NMFS can estimate the amount of mortality, existing data do not allow the precise causes to be determined. Candidate sources of mortality could include natural causes, impaired passage through the CRS because of high flow or spill, direct and indirect effects of harvest, increased straying, and delayed effects of marine mammal attacks incurred below Bonneville Dam. Recent improvements in PIT tag monitoring capabilities in the CRS will help identify the location and potential causes of the loss, and additional research or monitoring will likely be required to inform the formulation of solutions.

E.9 REFERENCES

Absolon, R.F., E.E. Hockersmith, G.A. Axel, D.A. Ogden, B.J. Burke, K.E. Frick, and B.P. Sandford. 2008. Passage Behavior and Survival for Radio-Tagged Subyearling Chinook Salmon at Lower Monumental Dam, 2007. Report to Walla Walla District, U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers Northwestern Division, Bureau of Reclamation Pacific Northwest Region, and Bonneville Power Administration (Corps et al.), 2017. Endangered Species Act. Federal Columbia River Power System, 2016 Comprehensive Evaluation.

Anchor QEA. 2017. Lower Granite Adult Passage and Post-passage Evaluation Final Adult Passage and Post-passage Behavior Report. Prepared for Army Corps of Engineers. Project 161163-0201.

Axel, G.A., E.E. Hockersmith, B.J. Burke, K. Frick, B.P. Sandford, W.D. Muir, and R.F. Absolon. 2010.

- Passage Behavior and Survival of Radio-Tagged Yearling and Subyearling Chinook Salmon and Juvenile Steelhead at Ice Harbor Dam, 2008. Report to Walla Walla District, U.S. Army Corps of Engineers.
- Beeman, J.W., Braatz, A.C., Hansel, H.C., Fielding, S.D., Haner, P.V., Hansen, G.S., Shurtleff, D.J., Sprando, J.M., and Rondorf, D.W., 2010, Approach, passage, and survival of juvenile salmonids at Little Goose Dam, Washington: Post-construction evaluation of a temporary spillway weir, 2009: U.S. Geological Survey Open-File Report 2010-1224, 100 p.
- Bellerud, B. 2016. BPA communication with NOAA Fisheries. Compiled annually for CE/APR from the PTAGIS database.
- Biomark and Quantitative (Biomark Inc. and Quantitative Consultants Inc.), 2012. Effects of Release History, Migration History, and Adult Detection Location on Smolt to Adult Return Rates for Snake River Sockeye Salmon. Submitted to U.S. Army Corps of Engineers. October 22.
2013. Federal Columbia River Power System Improvements and Operations Under the Endangered Species Act – A Progress Report.
- Buchanan, R., R. Townsend, J. Skalski, and K. Ham. 2011. The effect of bypass passage on adult returns of salmon and steelhead: an analysis of PIT-tag data using ROSTER. Report prepared for U.S. Army Corps of Engineers, Walla Walla District Office, by Battelle.
- Caudill, C., W. Daigle, M. Keefer, C. Boggs, M. Jepson, B. Burke, R. Zabel, T. Bjornn, and C. Perry, 2007. Slow dam passage in adult Columbia River salmonids associated with unsuccessful migration: delayed negative effects of passage obstacles or condition-dependent mortality? *Can. J. Fish. Aquat. Sci.* 64:979-995. Chapman, D., 1986. Salmon and steelhead abundance in the Columbia River in the nineteenth century. *Transactions of the American Fisheries Society* 115:662–670.
- Connor W. P., J. Sneva, K. Tiffan, R. Steinhorst, and D. Ross, 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River Basin. *Transactions of the American Fisheries Society* 134:291-303.
- Connor, W. P., and K. F. Tiffan. 2011. Research, Monitoring, and Evaluation of Emerging Issues and Measures to Recover the Snake River Fall Chinook Salmon ESU. Annual report 2008. Project Number 1991-029-00. Contract Number DE-AI79-91BP21708. Bonneville Power Administration, Portland, Oregon.
- Connor, W. P., K. F. Tiffan, J., J. M. Plumb, and C. M. Moffitt. 2013. Evidence for density –dependent changes in growth, downstream movement, and size of Chinook Salmon subyearlings in a large river landscape. *Transactions of the American Fisheries Society* 142:1453–1468.
- Deng, Daniel. “Characterization of the Ice Harbor Unit 2 Test Turbine: Preliminary Results.” Anadromous Fish Evaluation Program Annual Meeting, Richland, Washington, December 3, 2019. Ebel, W., and H. Raymond, 1976. Effect of atmospheric gas supersaturation on salmon and steelhead trout of the Snake and Columbia rivers. *Marine Fisheries Review* 38(7):1-14.
- Faulkner, J., B. Bellerud, D. Widener, and R. Zabel, 2019. Associations among fish length, dam passage history and survival to adulthood in two at-risk species of Pacific salmon. *Transactions of the American Fisheries Society*. 148:6, 1069-1087.

- Faulkner, J., M. Morris, D. Widener, T. Marsh, S. Smith, and R. Zabel, 2016. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2015. Report to Bonneville Power Administration for Project 199302900, dated February 2016. 151 p.
- Faulkner, J., D. Widener, T. Marsh, S. Smith, and R. Zabel, 2017. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2016. Report to Bonneville Power Administration for Project 199302900, dated April 2017. 115 p.
- Faulkner, J., D. Widener, S. Smith, T. Marsh, and R. Zabel, 2018. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2016. Report to Bonneville Power Administration for Project 199302900, dated April 2017. 115 p.
- Faulkner, J., S. Smith, W. Muir, D. Marsh, and R. Zabel, 2012. Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2011. Report to Bonneville Power Administration for Project 199302900, dated February 2012. 102 p.
- Faulkner, J. 2016. Personal communication with James Faulkner, NOAA Fisheries, April 10, 2016.
- Ferguson, J., G. Matthews, R. McComas, R. Absolon, D. Brege, M. Gessel, and L. Gilbreath, 2005. Passage of adult and juvenile salmonids through federal Columbia River power system dams. NOAA Tech. Memo. NMFS-NWFSC-64. 160 p.
- Giorgi, A., M. Miller, and J. Stevenson, 2002. Mainstem passage strategies in the Columbia River System: transportation, spill, and flow augmentation. Report to the Northwest Power Planning Council, 89 pages plus appendices.
- Gosselin, J. L., C. Van Holmes, S. Iltis, and J. J. Anderson. 2018b. Snake River Juvenile Salmon and Steelhead Transportation Synthesis Report. <http://www.cbr.washington.edu/papers>
- Graves, R. 2017. Declaration of Ritchie J. Graves, National Marine Fisheries Service, West Coast Region. United States District Court, District of Oregon, Case No.: 3:01-CV-00640-SI.
- Harnish, RA, KD Ham JR Skalski RL Townsend JM Lady KD Deters PS Titzler AH Colotelo T Fu X Li JJ Martinez Z Deng MK Nims EL McCann Y Yuan CL Grant. 2019. Yearling Chinook Salmon and Juvenile Steelhead Passage and Survival through the FCRPS, 2018. PNNL-28325, Pacific Northwest National Laboratory, Richland, Washington. PNNL-28325, Pacific Northwest National Laboratory, Richland, Washington
- Haeseker, S., J. McCann, J. Tuomikoski, and B. Chockley. 2012. Assessing freshwater and marine environmental influences on life-stage-specific survival rates of Snake River spring-summer Chinook salmon and steelhead. Transactions of the American Fisheries Society, 141:1, 121-138.
- Hockersmith, E.E., G.A. Axel, R. F. Absolon, B.J. Burke, K.E. Frick, J.J. Lamb, M.G. Nesbit, N.D. Dumdei, and B.P. Sandford. 2010. Passage behavior and survival for radio tagged yearling Chinook salmon and juvenile steelhead at Lower Monumental Dam, 2009. Report to the Army Corps of Engineers, Walla Walla, Washington.

- Holsman, K., M. Scheurell, E. Buhl, and R. Emmett. 2012. Interacting effects of translocation, artificial propagation, and environmental conditions on the marine survival of Chinook salmon from the Columbia River, Washington, U.S.A. *Conservation Biology* 26:912-922.
- Hostetter, N., A. Evans, F. Loge, R. O'Connor, B. Cramer, D. Fryer, and K. Collis. 2015. The Influence of Individual Fish Characteristics on Survival and Detection: Similarities across Two Salmonid Species. *North American Journal of Fisheries Management* Vol. 35, Iss. 5.
- Hughes, J.S., M.A. Weiland, C.M. Woodley, G.R. Ploskey, S.M. Carpenter, M.J. Hennen, E.F. Fischer, G.W. Batten III, T.J. Carlson, A.W. Cushing, Z. Deng, D.J. Etherington, T. Fu, M.J. Greiner, M. Ingraham, J. Kim, X. Li, J. Martinez, T.D. Mitchell, B. Rayamajhi, A. Seaburg, J.R. Skalski, R.L. Townsend, K.A. Wagner, and S.A. Zimmerman. 2013. Survival and Passage of Yearling and Subyearling Chinook Salmon and Steelhead at McNary Dam, 2012. PNNL-22788. Report submitted by the Pacific Northwest National Laboratory to the U.S. Army Corps of Engineers, Walla Walla, Washington.
- ISAB (Independent Scientific Advisory Board), 2007. Latent mortality report. NPCC document ISAB 2007-1, dated April 6, 2007. Report to Northwest Power and Conservation Council. Available online: <http://www.nwcouncil.org/>
- ISAB (Independent Scientific Advisory Board), 2012. Follow-up Review: FPC and CSS analyses of latent mortality of in-river migrants due to route of dam passage. NPCC Report ISAB 2012-1. Available online: <http://www.nwcouncil.org/>
- ISAB (Independent Scientific Advisory Board), 2014. Review of the Proposed Spill Study. NPCC Report ISAB 2014-2. Available online: <http://www.nwcouncil.org/>
- ISAB (Independent Scientific Advisory Board), 2018. Review of NOAA Fisheries Document: A Power Analysis of Two Alternative Experimental Designs to Evaluate a Test of Increased Spill at Snake and Columbia River Dams, Using Smolt-to-Adult Returns of Anadromous Salmonids. ISAB 2018-2. Available online: <http://www.nwcouncil.org/>
- ISRP (Independent Scientific Review Panel). 2009. Review of AFEP project – Statistical Design for the Lower Columbia River Acoustic-Tag Investigations of Dam Passage Survival and Associated Metrics. Memorandum to the NPCC. ISRP 2009-43. http://www.nwcouncil.org/media/33049/isrp2009_43.pdf
- Johnson, G.E., J.R. Skalski, T.J. Carlson, G.R. Ploskey, M.A. Weiland, Z. Deng, E.S. Fischer, J.S. Hughes, F. Khan, J.A. Kim, and R.L. Townsend. 2011. Survival and Passage of Yearling and Subyearling Chinook Salmon and Steelhead at The Dalles Dam, 2010. PNNL-20626, Pacific Northwest National Laboratory, Richland, WA.
- Keefer, M., and C. Caudill. 2012. A review of salmon and steelhead straying with an emphasis on Columbia River populations. Prepared for U.S. Army Corps of Engineers, Walla Walla District. Technical Report 2012-6.

- Marsh, T, Smith S., and Sandford B. 2015. A study to Evaluate Hydropower system related Latent Mortality Associated with Passage of Yearling Chinook Salmon Smolts through Snake River Dams, Final results 2005-2011. Annual report, BPA project 2003-041-00 <https://www.cbfish.org/Document.mvc/DocumentViewer/P142841/46273-81-1.pdf>
- McCann, J., B. Chockley, E. Cooper, T. Garrison, H. Schaller, S. Haeseker, R. Lessard, C. Petrosky and T. Copeland, E. Tinus, E. Van Dyke, R. Ehlke, and M. Dehart. 2016. Comparative Survival Study (CSS) of PIT-tagged spring/summer Chinook salmon and summer steelhead, 2016 draft annual report. Report to the Bonneville Power Administration -Project 1996-020-00. Prepared by the Comparative Survival Study Oversight Committee and the Fish Passage Center, Portland, Oregon.
- McCann, J, B Chockley, E Cooper, B Hsu, H Schaller, S Haeseker, R Lessard, C Petrosky, T Copeland, E Tinus E Van Dyke, A Storch, D Rawding, and M Dehart. 2017. Comparative Survival Study (CSS) of PIT-tagged spring/summer/fall Chinook, summer steelhead, and sockeye, 2017 Annual Report. Report to the Bonneville Power Administration -Project 1996-020-00. Prepared by the Comparative Survival Study Oversight Committee and the Fish Passage Center, Portland, Oregon.
- McCann, J, B Chockley, E Cooper, B Hsu, S Haeseker, R Lessard, C Petrosky and T Copeland, E Tinus, A Storch, and M Dehart. 2018. Comparative Survival Study (CSS) of PIT-tagged spring/summer/fall Chinook, summer steelhead, and sockeye, 2018 Annual Report. Report to the Bonneville Power Administration -Project 1996-020-00. Prepared by the Comparative Survival Study Oversight Committee and the Fish Passage Center, Portland, Oregon.
- McGrath, K.E., E.M. Dawley, D.R. Geist. 2006. Total dissolved gas effects on fishes of the Lower Columbia River. Report prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon – Project DE-AC05-76RL01830. PNNL-15525, Pacific Northwest National Laboratory, Richland, WA.
- NMFS (National Marine Fisheries Service). 2010. Analyses of juvenile Chinook salmon and steelhead transport from Lower Granite and Little Goose dams.
- NMFS (National Marine Fisheries Service). 2016. 2015 Adult Sockeye Salmon Passage Report.
- NMFS (National Marine Fisheries Service). 2017. 2017 Supplemental Recovery Plan Module for Snake River Salmon and Steelhead Mainstem Columbia River Hydropower Projects.
- Northwest Power Planning Council (NPPC). 1987. Columbia River Basin Fish and Wildlife Program. [Adopted November 15, 1982, Amended October 10, 1984 and Amended February 11, 1987.](#)
- Heisey, P. 2019. “Direct Injury and Relative Survival of Juvenile Spring Chinook Salmon Passing a New Turbine Designed for Safer Fish Passage at Ice Harbor Dams.” Anadromous Fish Evaluation Program Annual Review Meeting, Richland, Washington, December 3, 2019.
- Oregon Department of Fish and Wildlife. 2017. California Sea Lion Management, Restoring balance between predators and salmon. <http://www.dfw.state.or.us/fish/SeaLion/>.
- Perkins, TA, & HI Jager. 2011. Falling behind: delayed growth explains life-history variation in Snake River fall Chinook salmon. *Transactions of the American Fisheries Society*, 140(4), 959-972.

- Ploskey GR, MA Weiland, JS Hughes, CM Woodley, Z Deng, TJ Carlson, J Kim, IM Royer, GW Batten, AW Cushing, SM Carpenter, DJ Etherington, DM Faber, ES Fischer, T Fu, MJ Hennen, TD Mitchell, TJ Monter, JR Skalski, RL Townsend, and SA Zimmerman. 2011. *Survival and Passage of Juvenile Chinook Salmon and Steelhead Passing Through Bonneville Dam, 2010*. PNNL-20835, Final Report, Pacific Northwest National Laboratory, Richland, Washington.
- Ploskey, GR, MA Weiland, and TJ Carlson. 2012. Route-specific passage proportions and survival rates for fish passing through John Day Dam, The Dalles Dam, and Bonneville Dam in 2010 and 2011 (No. PNNL-21442). Pacific Northwest National Lab.(PNNL), Richland, WA (United States).
- Ploskey GR, GW Batten III, AW Cushing J Kim, GE Johnson, JR Skalski, RL Townsend, AG Seaburg, TJ Carlson, SM Carpenter, Z Deng, DJ Etherington, ES Fischer, T Fu, MJ Greiner, MJ Hennen, JS Hughes, JJ Martinez, TD Mitchell, B Rayamajhi, MA Weiland, CM Woodley, and SA Zimmerman. 2013. *Survival and Passage of Juvenile Chinook Salmon and Steelhead Passing Through Bonneville Dam, 2011*. PNNL-22178, Final Report, Pacific Northwest National Laboratory, Richland, Washington.
- Plumb, JM, AC Braatz, JN Lucchesi, SD Fielding, AD Cochran, T K Nation, JM Sprando, JL Schei, , RW Perry, NS Adams, and DW Rondorf. 2003. Behavior and survival of radio-tagged juvenile Chinook salmon and steelhead relative to the performance of a removable spillway weir at Lower Granite Dam, Washington, 2003
- RW Perry, NS Adams, and DW Rondorf. 2003. Behavior and survival of radio-tagged juvenile Chinook salmon and steelhead and performance of a removable spillway weir at Lower Granite Dam, Washington, 2003. Annual Report by the U. S. Geological Survey to the U. S. Army Corps of Engineers, contract W68SBV00104592, Walla Walla, Washington.
- Raymond, HL. 1979. Effects of dams and impoundments on migrations of juvenile Chinook salmon and steelhead from the Snake River, 1966 to 1975. *Transactions of the American Fisheries Society* 108:505–529.
- Rechisky, E, D Welch, A Porter, M Jacobs-Scott, P Winchell. 2013. Influence of multiple dam passage on survival of juvenile Chinook salmon in the Columbia River estuary and coastal ocean. *Proceedings of the National Academy of Sciences*, 110(17), 6883-6888.
- Reischel, T and T Bjornn. 2003. Influence of fishway placement on fallback of adult salmon at the Bonneville Dam on the Columbia River. *North Am. J. of Fish. Mangt.* 23:1215-1224.
- Ryding, KE and JR Skalski. 1999. Multivariate regression relationships between ocean conditions and early marine survival of coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Fisheries and Aquatic Sciences*, 56(12), 2374-2384.
- Sandford, B, R Zabel, L Gilbreath, and S Smith. 2012. Exploring Latent Mortality of Juvenile Salmonids Related to Migration through the Columbia River Hydropower System, *Transactions of the American Fisheries Society*, 141(2): 343-352.
- Scheuerell, MD, RW Zabel and BP Sandford. 2009. Relating juvenile migration timing and survival to adulthood in two species of threatened Pacific salmon (*Oncorhynchus* spp.) *Journal of Applied Ecology* 46: 983-990.

- Sims, C, and FJ Ossiander. 1981. Migrations of juvenile Chinook salmon and steelhead in the Snake River, form 1973 to 1979, a research summary. National Marine Fisheries Service, Seattle, Washington.
- Skalski, JR, GE Johnson, and TJ Carlson. 2010. Compliance Monitoring of Juvenile Yearling Chinook Salmon and Steelhead Survival and Passage at The Dalles Dam, Spring 2010. PNNL-19819, Final Report, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski, JR, GE Johnson, and TJ Carlson. 2010a. Compliance Monitoring of Juvenile Subyearling Chinook Salmon Survival and Passage at The Dalles Dam, Summer 2010. PNNL-20042, Final Report, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski, JR, RL Townsend, AG Seaburg, GE Johnson, and TJ Carlson. 2012a. Compliance Monitoring of Juvenile Yearling Chinook Salmon and Steelhead Survival and Passage at The Dalles Dam, Spring 2011. PNNL-21124, compliance report submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by Pacific Northwest National Laboratory, Richland, Washington and the University of Washington, Seattle, Washington.
- Skalski, JR, RL Townsend, A Seaburg, GR Ploskey, and TJ Carlson. 2012b. Compliance monitoring of Yearling Chinook Salmon and Juvenile Steelhead Survival and Passage at Bonneville Dam, Spring 2011. PNNL-21175, Final Report, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski, JR, RL Townsend, AG Seaburg, GR Ploskey, MA Weiland, JS Hughes, CM Woodley, Z Deng, TJ Carlson, and GE Johnson. 2012c. Compliance Monitoring of Subyearling Chinook Salmon Survival and Passage at The Dalles Dam, Summer 2012. PNNL-22195, compliance report submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by Pacific Northwest National Laboratory, Richland, Washington, and the University of Washington, Seattle, Washington.
- Skalski, JR, RL Townsend, AG Seaburg, JS Hughes, MA Weiland, GR Ploskey, CM Woodley, Z Deng, and TJ Carlson. 2012d. Compliance monitoring of yearling and subyearling Chinook salmon and juvenile steelhead survival and passage at McNary Dam, 2012. PNNL-22125, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski JR, RL Townsend, A Seaburg, MA Weiland, CM Woodley, JS Hughes, and TJ Carlson. 2012e. Compliance Monitoring of Yearling Chinook Salmon and Juvenile Steelhead Survival and Passage at John Day Dam, Spring 2011. PNNL-21176, Final Report, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski, JR, RL Townsend, AG Seaburg, GA McMichael, RA Harnish, EW Oldenburg, KD Ham, AH Colotelo, KA Deters, and ZD Deng. 2013a. BiOp Performance Testing: Passage and Survival of Yearling and Subyearling Chinook Salmon and Juvenile Steelhead at Lower Monumental Dam, 2012. PNNL-22100, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski, JR, RL Townsend, AG Seaburg, GA McMichael, EW Oldenburg, RA Harnish, KD Ham, AH Colotelo, KA Deters, and ZD Deng. 2013b. BiOp Performance Testing: Passage and Survival of Yearling and Subyearling Chinook Salmon and Juvenile Steelhead at Little Goose Dam, 2012. PNNL-22140, Pacific Northwest National Laboratory, Richland, Washington.

- Skalski JR, RL Townsend, AG Seaburg, GA McMichael, RA Harnish, EW Oldenburg, KD Ham, AH Colotelo, KA Deters, ZD Deng, PS Titzler, EV Arntzen, and CR Vernon. 2013c. *DRAFT BiOp Performance Testing: Passage and Survival of Subyearling Chinook Salmon at Little Goose and Lower Monumental Dams, 2013*. PNNL-22706, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski JR, RL Townsend, AG Seaburg, MA Weiland, CM Woodley, JS Hughes, GR Ploskey, Z Deng, and TJ Carlson. 2013d. *Compliance Monitoring of Yearling and Subyearling Chinook Salmon and Juvenile Steelhead Survival and Passage at John Day Dam, 2012*. PNNL-22152, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski JR, RL Townsend, A Seaburg, GR Ploskey, MA Weiland, JS Hughes, CM Woodley, Z Deng, and TJ Carlson. 2013e. *Compliance Monitoring of Subyearling Chinook Salmon Survival and Passage at Bonneville Dam, Summer 2012*. PNNL-22188, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski JR, RL Townsend, MA Weiland, CM Woodley, and J Kim. 2014. Compliance monitoring of subyearling Chinook salmon survival and passage at John Day Dam, 2014. PNNL-23951, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski, J.R., R.L. Townsend, M.A. Weiland, C.M. Woodley, and J. Kim. 2015. Compliance Monitoring of Yearling and Subyearling Chinook Salmon and Juvenile Steelhead Survival and Passage at McNary Dam, 2014. PNNL-23979, Pacific Northwest National Laboratory, Richland, Washington.
- Skalski, SR, MA Weiland, KD Ham, GR Ploskey, GA McMichael, AH Colotelo, TJ Carlson, CM Woodley, MB Eppard and EE Hockersmith. 2016. Status after 5 Years of Survival Compliance Testing in the Federal Columbia River Power System (FCRPS), North American Journal of Fisheries Management, 36:4, 720-730, DOI: 10.1080/02755947.2016.1165775
- Smith, S, DM Marsh, RL Emmett, WD Muir, and RW Zabel. 2013. A Study to Determine Seasonal Effects of Transporting Fish from the Snake River to Optimize a Transportation Strategy. Report of research by Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration. Prepared for Walla Walla District Northwestern Division U.S. Army Corps of Engineers. March.
- Smith, S. 2017. Smolt Survival and Travel Time & Transportation Analyses Update with 2016 Data. Briefing for Regional Implementation Oversight Group, Feb. 1, 2017.
- Tiffan, KF, TJ Kock, WP Connor, RK Steinhorst, and DW Rondorf. 2009. Behavioural thermoregulation by subyearling fall (autumn) Chinook salmon *Oncorhynchus tshawytscha* in a reservoir. *Journal of Fish Biology* 74: 1562-1579.
- Trushenski, JT, DA Larsen, MA Middleton, M Jakaitis, EL Johnson, CC Kozfkay, And PA Kline. (2019). Search for the Smoking Gun: Identifying and Addressing the Causes of Postrelease Morbidity and Mortality of Hatchery-reared Snake River Sockeye Salmon Smolts. *Transactions of the American Fisheries Society*. 148:5, 875-895.

- Tuomikoski, J., J. McCann, T. Berggren, H. Schaller, P. Wilson, S. Haeseker, J. Fryer, C. Petrosky, E. Tinus, T. Dalton, and R. Ehlke, and M. DeHart. 2011. Comparative Survival Study (CSS) of PIT-tagged spring/summer Chinook salmon and summer steelhead, 2011 annual report. Report to the Bonneville Power Administration -Project 1996-020-00. Prepared by the Comparative Survival Study Oversight Committee and the Fish Passage Center, Portland, Oregon.
- Waples, R.S., R. Zabel, M., Scheurell, and B. Sanderson. 2007. Evolutionary responses by native species to major anthropogenic changes to their ecosystems: Pacific salmon and the Columbia River hydropower system. *Molecular Ecology*. 17: 84-96.
- Weiland, MA, GR Ploskey, JS Hughes, CM Woodley, Z Deng, TJ Carlson, JR Skalski, and RL Townsend. 2012. Monitoring of Juvenile Yearling Chinook Salmon and Steelhead Survival and Passage at John Day Dam, Spring 2010. PNNL-22015, Final Report, Pacific Northwest National Laboratory, Richland, Washington
- Weiland, MA, GR Ploskey, JS Hughes, CM Woodley, Z Deng, TJ Carlson, JR Skalski, and RL Townsend. 2012. Monitoring of Juvenile Subyearling Chinook Salmon Survival and Passage at John Day Dam, Summer 2010. PNNL-22014, Final Report, Pacific Northwest National Laboratory, Richland, Washington.
- Weiland MA, CM Woodley, GR Ploskey, JS Hughes, J Kim, Z Deng, T Fu, ES Fischer, JR Skalski, RL Townsend, JP Duncan, MJ Hennen, KA Wagner, EV Arntzen, BL Miller, AL Miracle, SA Zimmerman, IM Royer, F Khan, AW Cushing, DJ Etherington, TD Mitchell, T Elder, GW Batten, GE Johnson, and TJ Carlson. 2013a. *Acoustic Telemetry Evaluation of Juvenile Salmonid Passage and Survival at John Day Dam, 2010*. PNNL-22177. Final report submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by the Pacific Northwest National Laboratory, Richland, Washington.
- Weiland, MA, CM Woodley, JS Hughes, J Kim, MJ Hennen, ES Fischer, JP Duncan, KA Wagner, SA Zimmerman, GR Ploskey, Z Deng, T Fu, JR Skalski, RL Townsend, AG Seaburg, GW Batten III, TJ Carlson, SM Carpenter, AW Cushing, T Elder, DJ Etherington, MJ Greiner, F Khan, JJ Martinez, AL Miracle, TD Mitchell, K Prather, B Rayamajhi, and IM Royer. 2013b. *Acoustic Telemetry Evaluation of Juvenile Salmonid Passage and Survival at John Day Dam, 2011*. PNNL-22266. Final report submitted to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by the Pacific Northwest National Laboratory, Richland, Washington.
- Weiland, MA, CM Woodley, EF Fischer, JS Hughes, J Kim, B Rayamajhi, KA Wagner, RK Karls, KD Hall, SA Zimmerman, J Vavrinc, III, JA Vazquez, Z Deng, T Fu, TJ Carlson, JR Skalski, and RL Townsend. 2015. *Survival and Passage of Yearling and Subyearling Chinook Salmon and Steelhead at McNary Dam, 2014*. PNNL-24522. Final report submitted by the Pacific Northwest National Laboratory to the U.S. Army Corps of Engineers, Walla Walla, Washington.
- Widener, D.L., J.M. Faulkner, S. Smith, T. Marsh, and R. Zabel. 2018. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2017. Report to Bonneville Power Administration for Project 199302900, dated February 2018. 119 p.

- Widener, D.L., J.M. Faulkner, S. Smith, T. Marsh, and R. Zabel. 2019. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2018. Report to Bonneville Power Administration for Project 199302900, dated April 2019. 116 p.
- Williams, JG, SG Smith and WD Muir. 2001. Survival Estimates for Downstream Migrant Yearling Juvenile Salmonids through the Snake and Columbia Rivers Hydropower System, 1966-1980 and 1993-1999. *North American Journal of Fisheries Management*. 21:2. 310-317.
- Williams, J.G., S.G. Smith, R.W. Zabel, W.D. Muir, M.D. Scheuerell, B.P. Sandford, D.M. Marsh, R.A. McNatt, and S. Achord. 2005. Effects of the federal Columbia River power system on salmonid populations. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-63, 150 p.
- Zabel, R.W., B. Kennedy, W. Connor, P. Chittaro and J. Hegg. 2012. Identifying overwintering location and natal origin for Snake River fall Chinook salmon. Report for the Walla Walla District, U.S. Army Corps of Engineers.
- Zabel, R. 2012. Preliminary survival estimates for passage during the spring migration of juvenile salmonids through Snake and Columbia River reservoirs and dams, 2012. Memorandum to Bruce Suzumoto dated October 12, 2012.
- Zabel, R. 2019. Preliminary survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2019. Memorandum to Ritchie Graves dated September 19, 2019.

**Consultation Package for
Operations and Maintenance of the
Columbia River System**

**APPENDIX F – REFERENCES FOR THE SNAKE RIVER SPRING/SUMMER CHINOOK
SALMON EXAMPLE SURVIVALS BY LIFE STAGE**

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

F.1 ILLUSTRATING SALMON SURVIVAL BY LIFE STAGE

The table below documents the sources of scientific information and data that were used for Section 1.4 (Chapter 1) and (shown below as Figure F-1). The figure is intended to illustrate typical survivals by life stage and typical amounts of time that Snake River (SR) spring/summer Chinook salmon spend migrating past the Columbia River System (CRS) facilities and reservoirs in comparison to time away from the System. These types of biological data are often highly variable. For example, robust survival data are available for passage through the CRS, whereas data for ocean survival are less available. Mortality from all sources is incorporated in the survival estimates because, in many cases, different sources of mortality cannot be identified. For example, juvenile survival through the CRS reach from Lower Granite Dam to Bonneville Dam includes natural mortality, mortality related to the CRS, and mortality from any other source, such as toxics or predation. Any latent or delayed mortality related to CRS passage or any other source would be captured in juvenile migration survivals below the System, or in first year ocean survival.

Salmon mortality is related to multiple factors (National Research Council 1996). One of those is distance traveled during migration. For example, Faulkner et al. 2017, Figure 7, showed a statistically significant inverse relationship between survival of yearling hatchery Chinook salmon and distance from the hatchery release site to Lower Granite Dam. In Figure F-1, we used data for similar migration distances, where possible.

Mortality can also be a function of time; that is, higher mortality would be expected during longer life stages (a 1-year period vs a 2-week period). If the data shown in Figure F-1 were reported by equal time units, the mortality rate associated with juvenile salmon migration through the CRS would be relatively high. This relatively high mortality rate, in comparison to other life stages, is mostly an artifact of the way the data are presented in this particular figure. Actual critical periods of high mortality (e.g., egg-to-emergence; ocean entry) are relatively short (typically on the order of a few weeks), but for figure purposes are lumped into longer life stages (e.g., egg-to-smolt; first year ocean). This has the effect of reducing the mortality rate during these longer periods. Again, the figure is intended to roughly illustrate time and survivals near CRS facilities in contrast to time and survivals away from CRS facilities.

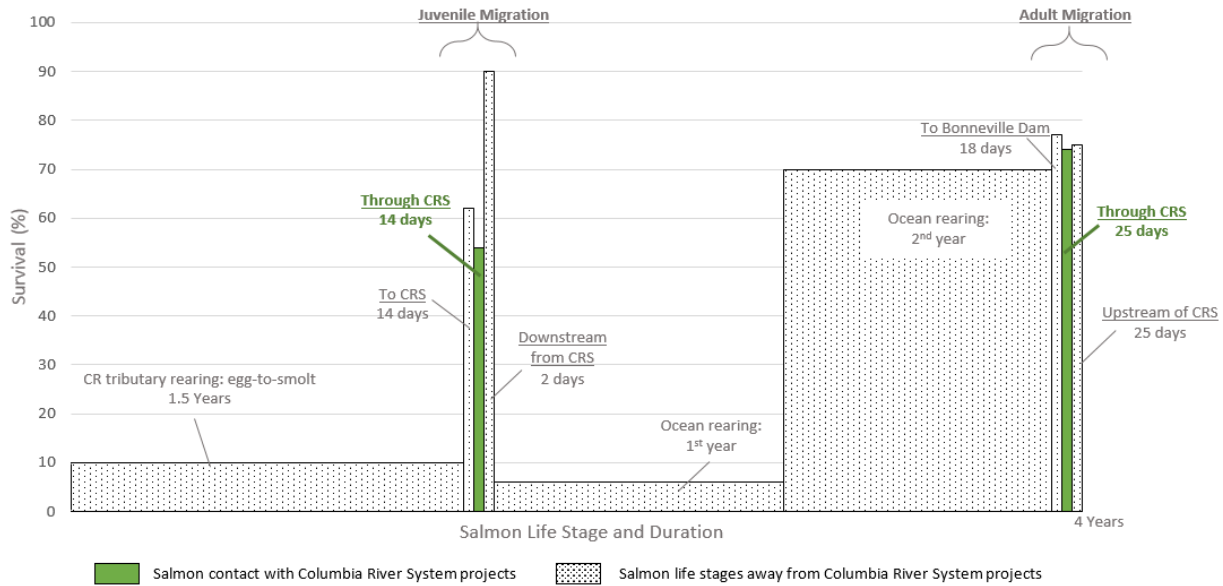


Figure F-1. SR spring/summer Chinook salmon example survivals by life stage

The y-axis shows approximate percent salmon survival by life stage. The x-axis and bar widths represent the approximate duration of each life stage, from egg through adult migration to the spawning grounds. Life stages shown here include juvenile rearing in Columbia River tributaries (egg-to-smolt), juvenile migration to the most upstream CRS dam, juvenile migration through the CRS, juvenile migration below the CRS to the ocean, first year ocean rearing, second year ocean rearing, adult migration from the ocean to the most downstream CRS dam, adult migration through the CRS and adult migration upstream of Lower Granite Dam. We assumed a 4-year life cycle for this example.

Table F-1. Summary of reference material for Figure F-1

Life Stage	Duration	Survival
Egg-to-smolt	1.5 years (e.g., October 2016 to March 2018): NMFS 2008, page 8.3–11. Spawning is usually complete by second week of September.	10% average: Quinn 2005, Table 15-1, p 254. The expert panel process used 18% as a <i>maximum</i> survival as explained/ documented in Corps et al. 2007, Appendix C, Attachment C-1, Annex 2, pages C-1-24 to C-1-26. Annex 2 reports a range of 1–22% for survivals. Paulsen and Fisher 2005, Figure 2, Reports <u>parr-to-smolt</u> survivals for SR spring/summer Chinook of about 20%.
Juvenile migration to the CRS	Assumed 14 days because the distance to Lower Granite Dam from the hatchery release site is similar to the distance through the CRS: Faulkner et al. 2017, p 31.	62%: Faulkner et al. 2017, p 46. McCall hatchery was used because this distance, 457 km, is similar to the 461 km from Lower Granite Dam to Bonneville Dam. Data an average of 2007–2016. Means for this set of years ranged from 51–73%.

Life Stage	Duration	Survival
Juvenile migration thru the CRS	14 days: Personal communication with Christine Peterson, Bonneville Power Administration Faulkner et al. 2017, p 31, chart upper right. Variation is about 10–32 days depending upon time of year.	54%: Faulkner et al., 2017, p 49. Data an average of 2007–2016 data. This number incorporates natural mortality and all other sources of mortality (for example toxics from any source) – not just mortality related to CRS operations. Means for this set of years ranged from 43–63%.
Juvenile migration downstream of Bonneville Dam to the ocean	2 days: NWFSC (Northwest Fisheries Science Center) 2014, p 19.	90%: Used 90% from range of 81–99% reported on p 41, Jacobson et al. 2012.
First year ocean	1 year	6%: Based on data presented on page 41, Jacobson et al. 2012, reporting ranges from 14–71% for survival in the plume (from the mouth of the Columbia to Willapa Bay) and 2–25% from Willapa Bay to Lippy Point, Vancouver Island. We used midpoints of these 2 values - $42.5\% * 13.5\% = 6\%$ and see page vi, last bullet. L. Weitkamp presentation to Northwest Power and Conservation Council, Jan 3, 2018, slide 4, says “This initial period is when most marine mortality occurs.”
Second year ocean	1 year	70%: Sharma et al. 2013, p 15
Adult migration to Bonneville Dam	18 d: NWFSC 2014, p 22.	77%: NMFS 2017a, p 34. 2017 supplemental recovery plan module for SR salmon and steelhead mainstem Columbia River hydropower projects. Represents an average for SR spring Chinook (2010–2016).
Adult migration thru the CRS	Assumed 20 km/day or 25 days: NWFSC 2014, p 8, and Ferguson et al. 2005, p 103.	87%: P 9, NMFS 2017a. (Corrected for harvest and straying; otherwise 74%).
Adult migration upstream of the CRS to the spawning ground	Assumed 20 km/day or 25 days: NWFSC 2014, p 8, and Ferguson et al. 2005. p 103.	75%: P 73, NMFS 2017b (this is an assumption used by NMFS; actual mortalities would vary with distance traveled and other factors).

F.2 REFERENCES

- Corps, BPA, Reclamation 2007. US Army Corps of Engineers, Bonneville Power Administration, Bureau of Reclamation. 2007. Comprehensive analysis of the Federal Columbia River Power System and mainstem effects of Upper Snake and other tributary actions. Portland, Oregon, August, 2007.
- Faulkner et al. 2017. Faulkner, J.R., D.L. Widener, S.G. Smith, T.M. Marsh, and R.W. Zabel. 2017. Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2016. Fish Ecology Division, Northwest Fisheries Science Center. Seattle, Washington.
- Ferguson et al. 2005. Ferguson, J.W., G.M. Matthews, R.L. McComas, R.F. Absolon, D.A. Brege, M.H. Gessel, and L.G. Gilbreath. 2005. Passage of adult and juvenile salmonids through Federal Columbia River Power system dams. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-64, March 2005.
- Jacobson et al., 2012. K., B. Peterson, M. Trudel, J. Ferguson, C. Morgan, D. Welch, A. Baptista, B. Beckman, R. Brodeur, E. Casillas, R. Emmett, J. Miller, D. Teel, T. Wainwright, L. Weitkamp, J. Zamon and K. Fresh. 2012. The marine survival of juvenile Columbia River Basin salmonids: a synthesis of research 1998-2011. Report to the Northwest Power and Conservation Council.
- National Research Council 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press. Washington, D.C.
- NMFS (National Marine Fisheries Service). 2008. Supplemental comprehensive analysis of the Federal Columbia River Power System and mainstem effects of the Upper Snake and other tributary actions. NMFS, Portland, Oregon, 5/5/2008.
- NMFS (National Marine Fisheries Service). 2017a. 2017 supplemental recovery plan module for Snake River salmon and steelhead mainstem Columbia River hydropower projects. West Coast Region. Portland, Oregon. September 2017.
- NMFS (National Marine Fisheries Service). 2017b. Final environmental impact statement to analyze impacts of NOAA's National Marine Fisheries Service joining as a signatory to a new U.S. v. Oregon management agreement for the years 2018-2027.
- NWFSC (Northwest Fisheries Science Center). 2014. Draft module of the ocean environment. Prepared for NOAA Fisheries Northwest Regional Office.
- Paulsen and Fisher 2005. Paulsen, Charles M. and Timothy R. Fisher. 2005. Do habitat actions affect juvenile survival? An information-theoretic approach applied to endangered Snake River Chinook salmon. Transactions of the American Fisheries Society 134: 68-85.
- Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. American Fisheries Society Bethesda, Maryland in association with University of Washington Press, Seattle and London. 378 pp.
- Sharma et al. 2013. Sharma, R., L.A. Velez-Espino, A.C. Wetheimer, N. Manua, and R.C. Francis. 2013. Relating spatial and temporal scales of climate and ocean variability to survival of Pacific Northwest Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 22:1, 14-31.

Weitkamp, L. 2018. Update on ocean conditions. Memorandum and presentation from Patty O'Toole and Laurie Weitkamp, Northwest Fisheries Science Center, to Northwest Power and Conservation Council members. January 3, 2018.